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American Prosperity the Cause of Foreign Jealousy

The debacle of the franc has served to excite in France a torrent of abuse of America. French criticism has apparently had its effect in England also, for many English editors and politicians are declaring that the burden of English debt to America is the main cause of their hard times. Our own prosperity is regarded by them as being the result of the world war, from which we are regarded as having profited hugely.

Of course all these reasons for European poverty and American prosperity have not a shadow's worth of substance. But America will long remain the victim of foreign ignorance, nevertheless, for ignorance is peculiarly long lived.

With only 5 per cent of the world's land area and 6 per cent of its population, America owns the following percentages of the world's wealth:

Gold (coin and bullion)	40
Railway mileage	37
Telephones	61
Telegraph (miles of wire)	30
Automobiles	84
Water power (developed)	40

Of the world's total annual production America supplies the following percentages:

Cotton	71
Coal	50
Petroleum	64
Pig iron	52
Copper	59
Lead	48
Timber	52

The slightest consideration of these figures makes it evident that if our prosperity is proportional to our present per capita productivity, the world war had nothing to do with our prosperity. Our per capita productivity before the world war was vastly greater than that of the people of the old world, and since the war it has increased only at its usual rate of increase (about 2 per cent annually) whereas theirs has decreased. Their loss has not been our gain, but has served to emphasize the gap between our productivity and theirs. Had the war not occurred America would be better off today, but the war led to such an upset in the currency of nearly every country in Europe that their business suffered tremendously in consequence.

Had Europe not committed the blunder of inflating its currency enormously, it would doubtless enjoy relative prosperity today. Whether through crass stupidity or, what is worse, a desire virtually to repudiate its borrowing from its own citizens, nearly every European nation increased its money several fold. The effect has been to increase money wages and prices proportionately. This would not have unsettled business very long, had money inflation come to an end quickly. But once started on the toboggan, the rouble, the mark, the lira and the franc skidded with increasing velocity toward nothingness in value. The splash that the French franc is about to make as it disappears has aroused France to a frenzy. Veterans of the war parade the streets of Paris in silent protest against—what? The stupidity of their politicians? No, against America's request that France repay the money borrowed since the armistice—all the debt incurred prior thereto having been wiped off by America without a cent of remuneration, for that is what the debt settlement offer amounts to.

Lloyd George charges America with having undermined European prosperity by asking interest on a fraction of what America loaned to Europe. Doubtless his charge also springs

from ignorance. If so, it serves to throw the calcium on an ignorance that is appalling. He too, then, joins the throng of the eloquent but "dumb."

By as much as European politicians demonstrate either their ignorance or their selfishness, it becomes more evident that Americans should avoid the nostrums that our own politicians of similar ignorance or selfishness are always preparing to feed us. The great game of the ignorant politician consists in promising what he can not deliver, and then blaming some one else for his failure to deliver according to promise.

H. P. Gillette

A Menace to the Portland Cement Industry

If protection of home industries is to remain a national policy, the time has arrived to increase the tariff on portland cement, for during the first quarter of this year nearly $2,000,000 of cement was imported. This is about double the importation during the first quarter of 1925. The rapid increase clearly indicates the seriousness of the situation.

Foreign cement sells at Atlantic coast points at 40 to 60 ct. a barrel below the price of domestic cement. About 75 per cent of the cement comes from Belgium, and 20 per cent from Denmark and Faroe Islands. Curiously enough, much of it is brought in U. S. Shipping Board vessels. Thus a "merchant marine" built to extend American commerce abroad, is being used, in this instance, to cripple American industries at home.

The present producing capacity of American cement mills is about 200,000,000 barrels annually, and it will be only a few months before this is increased to about 210,000,000 barrels. Last year (1925) was the greatest year for cement consumption. About 158,000,000 barrels were marketed, or less than 80 per cent of the then capacity of the mills.

The investment in the American cement industry is conservatively estimated at half a billion dollars. This vast industry has been built up largely as a result of the educational work carried on for many years by the cement manufacturers who are associated in an educational research enterprise known as the Portland Cement Association. If foreign producers are allowed the benefit from this educational work, it will be at the expense of American cement manufacturers and their employees.

Although a score of cement mills are operating within a few miles of Philadelphia, in the celebrated Lehigh District, we understand that not a single barrel of domestic cement is being used on the several million dollars' worth of street work now in progress in Philadelphia. Such instances make it clear that the importation of cement has already reached serious proportions.

It might be inferred that only American cement manufacturers will suffer much from this foreign competition, but it should be remembered that their employees will be the greatest sufferers. Moreover, there is an ever widening wave of distress caused by any serious disturbance in any large industry. For example, the employees of textile mills that make cement bags will be seriously affected. Railway employees engaged in transporting cement will be hit. Coal miners who produce coal for cement manufacture, for textile manufacture, and for rail transportation will be affected. And all this is only near the origin of the wave of disturbance, and only a part of the disturbance near the origin.

We need not dwell on the irresponsibility of foreign cement manufacturers as to their product. Nor on the risks that exist in cement structures, where the cement lacks the proper strength. These are minor matters compared with the very grave matter of injury to a great American industry, with its consequent injury not only to the employees in that industry but to all who are cooperative units in producing and transporting the raw materials from which cement is made, as well as the finished product.

Highway Research Work

The Committee on Tests and Investigations of the American Association of State Highway Officials has under way a number of interesting research projects. These projects, which are being conducted co-operatively by its various members, include a study of the relation between the quality of Portland cement as determined by the usual specification tests and the quality of the concrete in which the cement is used, a study of stone screenings in place of sand as fine aggregate in concrete, studies of the value of rail steel as reinforcing for concrete, studies of subgrade materials and methods of testing, and studies of methods for testing the stability of bituminous mixtures. Progress reports covering the use of stone screenings as fine aggregate and rail steel as reinforcing have already been made to the committee.

Washington Report on Tire Wear.—The second progress report on "The Relation of Road Surfaces to Automobile Tire Wear," by H. J. Dana, has been issued by the Engineering Experiment Station of the State College of Washington as Bulletin No. 17. This bulletin reports the tests conducted during the summer of 1925.

America's Annual Automobile Bill

To the Editor:

I have read with some bias in favor of your viewpoint the article in the July Roads and Streets entitled "A Grossly Erroneous Estimate of America's Annual Automobile Bill," as I firmly believe that the nation is fed up with wild, exaggerated statistics, impracticable, theoretical test results and unwarranted economic assumptions.

The subject matter of the article, however, is susceptible to a fair degree of verification, and somewhat to my surprise I find, in glancing over a report from the National Automobile Chamber of Commerce, that the conclusions of the Bureau of Industrial Technology, which you so sweepingly condemn, have considerable justification.

First, I find that the wholesale value of automobiles and parts produced in 1925 was $4,210,174,963, of which $308,333,584 represented exports. Against this latter figure should be credited $1,064,975 of imports, leaving a net value of $3,902,906,354. The value of fuels and lubricants sold by service stations and repair shops in 1923 was given as $2,100,000,000, and the value of service labor at stations and repair shops at $910,000,000. Insurance paid in 1925 was given as $258,136,775, and taxes were stated to have been $666,944,345. How much of these taxes were represented by the figures given for wholesale value of cars and parts and the amount reported as received for fuel and lubricants cannot be definitely stated, but of the total, $375,619,621 comprise registration fees, personal property and municipal taxes and exclude excise taxes and gasoline taxes. To be perfectly conservative, let us take the latter figure. The total of these five items is $7,546,662,750. I do not know what amount is collected by the automobile dealer over and above the wholesale value of the car and parts, but it would surely be at least 15 per cent. Taking the latter figure, however, gives us another item of $585,435,000, which boosts the total to $8,132,107,750.

The National Automobile Chamber of Commerce has carefully figured the average life of a car now at eight years. Depreciation, if you figure the average car as worth only $800, would be $100 per annum. You can omit from the calculation as many million cars as you care to omit in arriving at a proper total to use as a basis for figuring depreciation, and you still get a very sizeable item. Even if you figure depreciation at this rate as operating on only 15,000,000 cars, you have $1,500,000,000 as the depreciation item. Interest would of course depend upon how you figure it, but the $500,000,000 amount used in the article, which you seem to think conservative, certainly appears to me to be so. We have now arrived at a total of $10,132,000,000. Garage space is almost entirely a question of estimate as the cost may range from almost nothing to $50.00 a month per car, but if you consider an average as low as $3.00 per month per car, you have a grand total of $720,000,000, which gets us pretty close to $11,000,000,000, and when we consider that 1926 is showing an increase in the number of cars, gallons of gasoline, etc., it does not seem unreasonable to put the figure somewhere in the neighborhood of $12,000,000,000.

To my mind, the real significance of these huge expenditures is that they emphasize the necessity of more miles of reasonably good highway rather than the concentration of so much of our highway budget on relatively few miles. While it may seem that I have an "axe to grind" in stressing the importance of salvaging our old macadam and gravel roads, I do believe that a dispassionate study of the relation of the motor vehicle to the highway must result in the conviction that we must not only increase our highway budget but spread it over more miles and give more people adequate highway service.

While we are on the subject of misleading statistics, it may not be amiss to call attention to the general disposition of the advocates of costly highways to rub it in on the much abused gravel and macadam roads by playing up tire wear, gasoline and high maintenance costs and studiously ignoring annual interest requirements.

J. E. PENNYBACKER,
General Manager,
New York, N. Y. The Asphalt Association.

Government Aid in Road Building in Canada.—The Canadian Good Roads Association at its meeting at Montreal, May 13, adopted several important resolutions. One called for the Federal Government to render greater financial assistance to the provinces in road building, pointing out that the Federal Government collects millions in customs duties on automobiles and other products as a direct result of highway construction. At the present time the Government pays 40 per cent of the cost of highways. Several recommendations dealing with the problem of level railway crossings in Canada were passed. One resolution recommended that the Board of Railway Commissioners Act be amended so as to permit a maximum expenditure of $30,000 instead of $15,000 for work at any one crossing and that the percentage of assistance from the railroad be 50 instead of 25 as at present.

Highway Lighting

Recent Developments Outlined in Committee Report Presented June 10 at Annual Convention of Pacific Coast Electrical Association

Everyone recognizes he importance of highways in the great development of the Pacific Coast. Consider what a loss it would be if the usefulness of a large percentage of highways were destroyed. Such a loss would amount to a great calamity and would check the growth and prosperity of the entire community.

On the other hand if the usefulness of these highways is materially increased we are bound to have a corresponding increase in development and prosperity. Today adequate highway lighting is recognized as the solution to the problem of increasing the capacity of existing highways to accommodate the tremendous increase in motor car traffic.

The problem of adequately lighting a highway at reasonable cost was solved by the development of units especially designed to meet the requirements. Such units consist of reflectors or refractors which direct all of the available light of a small lamp in two beams along the road surface. By this concentration of light along the road there is no light wasted upward or outside the highway.

Lamp Size Spacing and Height.—With 2,500-lumen lamps spaced 300 ft. on one side only, the highway becomes a ribbon of light and driving with dimmed and even without headlights is safe. The 300-ft. spacing is preferable, but good results are possible within a range of from 250 to 400 ft. Spacing must vary, of course, to conform to existing pole spacings in many cases.

Because of the concentration of light and wide spacings highway units should be mounted 30 to 35 ft. to light center. This removes any glare from concentrated light by placing it above the line of vision and permits the necessary spread for an even distribution.

Cost.—The relatively small cost of lighting compared with the cost of highway construction and maintenance is shown in Fig. 1. The maintenance includes interest at 6 per cent and depreciation on the investment amounting to 10 per cent for macadam, 5 per cent for reinforced concrete, and 20 per cent for lighting equipment is based on 300-ft. spacing, with 250-cap. "Mazda C" series lamp 30 ft. above roadway.

The investment shown above for highway lighting includes new pole line installed for the lighting units. This investment will be materially decreased where existing pole lines are used. It is estimated that such installations will cost installed about $1,700 per mile.

Lincoln Highway Lighting Installation.—Perhaps the most interesting test of modern highway lighting has been the lighting of the ideal section of the Lincoln Highway in Indiana. Here the results were very carefully noted as this was a model highway. Therefore it should be of interest to know that officials of the Lincoln Highway Association predict that within the next decade the entire 960 miles of highway between New York and Chicago will be illuminated. They believe that the increase in traffic and particularly the development of freight transport by fleets of trucks operating at night when passenger traffic is at a minimum, will make lighting absolutely necessary.

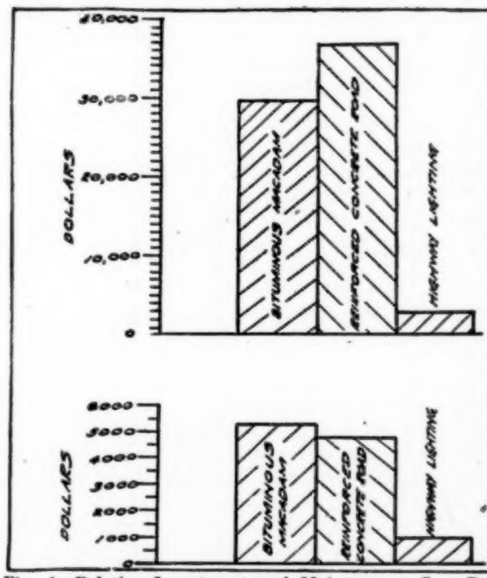


Fig. 1—Relative Investment and Maintenance Cost Per Mile of Highways and Lighting

It is significant that these authorities are beginning to refer to highway lighting as an absolute necessity. And it is a necessity, just the same as anything else on which depends an important part of our modern transportation system. Not only is it necessary to facilitate night trucking, but it is a vital necessity from the standpoint of public safety.

The annual loss of life and serious injury due to automobile accidents is appalling and is receiving widespread attention. A large percentage of these accidents occur at night due to inadequate or improper lighting. Headlight glare causes many accidents and this menace does not exist on a properly lighted highway. Modern highway lighting eliminates headlight glare because it removes the cause, which is contrast between the brilliant headlight and a dark background.

Precast Concrete Curbing

Many Curbing Troubles Eliminated by Use of Factory Made Units

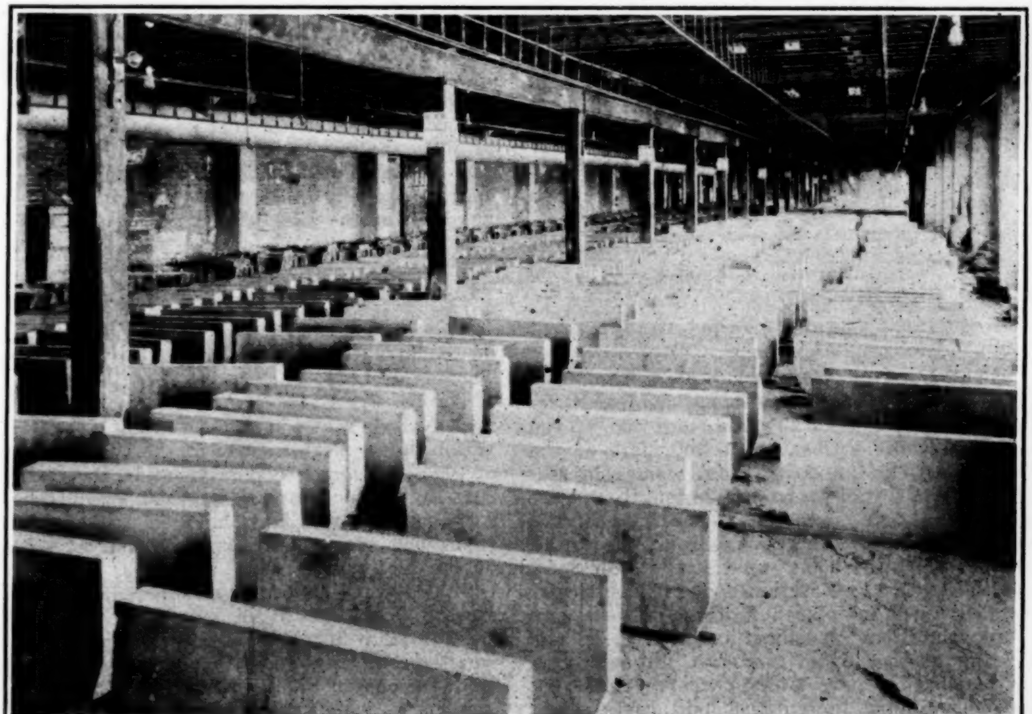
Concrete curbing, of the precast, cast in place or integral type has become standard construction on most of the better concrete and asphalt street construction projects. With the widespread adoption of concrete as a street paving material, methods and machines for speeding and bettering construction have been so perfected that first class construction is assured. Building the concrete curb on the job, however, still requires the most expert individual workmanship and constant supervision to insure dense, strong and permanent curbs.

An interesting attempt to bring uniformity to the building of concrete curbs has resulted in the adoption precast curbs in several cities, notably New Orleans, Buffalo, Tonawanda, Lackawanna and other western New York state cities. The precast curbs adopted in these cities insures the uniform strength, density and appearance so desirable in street paving work.

The built on the job concrete curb is less costly than the stone curb, but necessitates workmanship which is not always easy to get and requires a high degree of workmanship in order that each unit shall have an appearance similar to all other units and which will be uniformly dense and strong. Working up the rounded corner calls for skill on the part of the workman in order that the concrete mass shall be dense all the way through, and that the curve of the nose shall not vary from section to section. Careless workmanship is apt to result in a too sharply rounded corner which defeats the end sought in so far as appearance is concerned.

Advantages of Precast Curbs.—There are several advantages set forth for the precast curb. The first and most important advantage has to do with the matter of quality.

In a factory-made curb the section is cast upside down in a mold and the mix rodded or spaded into a dense, uniform mass. Then, too, there is the matter of materials. In the manufacturing plant, constant supervision over the materials, the mix and the casting

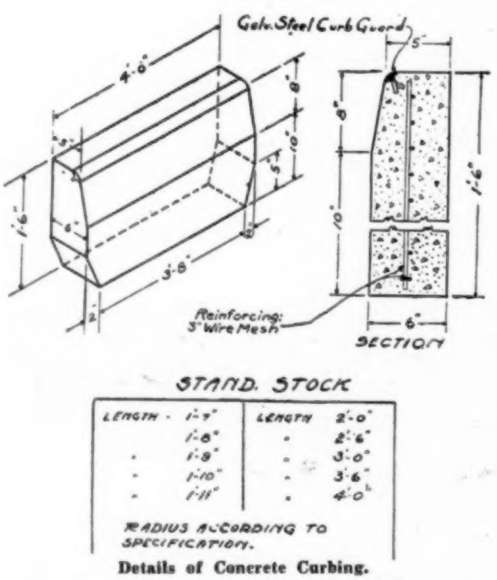


Precast Concrete Curb Units in Factory.

eliminates most of the troublesome operations typical in the field. A constant ratio of water to cement can be maintained, and the grading of the aggregates checked to insure density and strength.

In the field, curbing gets more than and often less than the amount of curbing given the pavement. In the curbing plant, sections are steam cured for thirty days before being shipped to the job. This insures high initial strength, lessens breaking and eliminates most of the curing troubles which make weak curbing sections.

In appearance the factory made units are usually higher in uniformity than those made in the field. Being cast in molds, each curve, line and corner corresponds with those of every other unit. Such is impossible under



Details of Concrete Curbing.

the conditions prevailing on the average street paving job.

Type Used in New York State.—The western New York cities mentioned have used precast curbs for several years, and one of the largest plants is located in that part of the country. The standard design comes in sections from 1 ft. 7 in. to 4 ft. in length and are 1 ft. and 6 in. in height. The base of the sections is 6 in. thick and 5 in. at the top, a batter of 1 in. being used in the top 8 in. of the section. A section of 3 in., electrically welded mesh is placed in each unit to give strength. Some specifications call for a steel nosing at the top of the curb, although this is omitted on many streets where vehicle unloading against the curb seldom occurs. After several years of use in New York state this type of curb shows no signs of wear and is in as excellent shape as when placed in the street.

Boulevard Type of Curb.—In all types of concrete curbing, whether precast, integral or curb and gutter, a decided trend is noticeable toward the adoption of what was once known as the boulevard type of curb. This type takes its name from the fact that it was formerly used on streets designed to present the most attractive appearance. This curb is identical in measurements with the unit explained before, but has a 2 in. batter in the upper 8 in. and the radius of the top curve is greater. This gives a sloping, gently rounded curb which adds to the appearance of the street.

In this type of curb the steel nose is omitted because the shape of the curb does away with the necessity for a reinforced nose. The slope of the curb and the rounded nose prevents cracking under impact, tending more to slide the wheel up onto the curb that to serve as an impact breaker.

The wearing qualities of any curb depend upon two general factors: The strength of the curb and the service it must undergo. In the precast type of curb, the sloping side and rounded nose reduce wear and constant adherence to control of the concrete mix to give concrete of high strengths assures the precast type of curb an indeterminate life.

In most of these plants a 1:2:3 mix is employed. Cement of standard specifications and torpedo sand (grits) and gravel are used as the aggregate form the batch. The coarse aggregate runs from ¾ in. to 1 in. in size. The consistency of the mix is just wet enough to allow the mix to fill the form with rodding. The strength developed exceeds 3,000 lb., a degree of strength seldom attained in an average built on-the-job curbing.

Cars to Be Lighter and Smaller

American supercraftmanship will be reflected in automobiles of the future, asserted Thomas J. Litle, Jr., president of the Society of Automotive Engineers, at the summer meeting of the society in June. From his observation of the performance of the tiny engines of 91½ in. piston displacement in the racing cars in the Indianapolis 500-mile sweepstakes race on Memorial Day, he predicted that we shall soon see on the American market some of the high-speed "toy" engines, probably equipped with some form of supercharging device. These will fit in nicely with cars of the future, which he said must be lighter and smaller than any we are using now but must be luxurious in riding comfort. It is uneconomical to use a vehicle weighing two or three tons to transport one or two passengers.

Rebuilding a 33-Mile Gravel Road

Methods and Costs of Scarifying, Blading, Removing Oversize Rock and Repairing Washouts

In the extreme southwestern part of New Mexico a Federal Aid Project was constructed a number of years ago. The project was 33.4 miles in length and was constructed as a 12-ft. gravel surface, 6 in. in depth, on a 20-ft. road-bed.

This road is a link in the Borderland Highway, which is the main highway through Texas and Southern New Mexico, Arizona and California.

When the road was completed it gave every indication of being a first-class road, but in a short time large oversize boulders of gravel began to show up in the surfacing. The metal of the road soon became so rough that the traffic began to edge out on the side and before long all the travel began to run in one rut along the shoulder. The maintenance force attempted to make repairs, but could accomplish little on account of the lack of necessary equipment and funds.

Drainage Structure.—During the late summer of 1923, heavy rains fell in this vicinity. The drainage structures were not able to take care of even the ordinary runoff satisfactorily, and they proved entirely inadequate to handle the excessive flow during this period. As a result, the water poured over the road, washing out parts of the gravel and shoulders, thus further adding to the maintenance difficulties.

The road was in striking contrast to the well-maintained roads immediately across the line in Arizona. Many epithets were hurled at New Mexico by the passing tourist, and much unfavorable comment was heard from all sides.

Early in 1924 the state and Federal authorities discussed methods and means of bettering these conditions. Again a shortage of funds prevented any extensive improvements, but it was decided to reopen the project for additional drainage, and this was done during the summer of 1924. Extra culverts and spillways were installed, and ditches and dikes were built to prevent the water from running over the road-bed and to carry it to the drainage structures. The work was let by contract and was completed at a cost of about $900 per mile for the length of the project.

So far nothing had been done with the surfacing. During the drouth of 1924 and the spring of 1925, the gravel and shoulders began to ravel and the road became almost impassable. Something had to be done. By this time the new gasoline tax had gone into effect and funds were beginning to come in. It was at first believed that the project should be reopened and rebuilt with the assistance of Federal funds, but quick action was necessary and it was then decided that the work should be done with state forces and without Federal aid.

Method of Rebuilding.—The method to be pursued was to scarify the surface, throw out the oversize and reshape the grade. Accordingly, the necessary equipment was placed on the south end of the job as soon as possible. A new 10-ft. grader and a heavy scarifier weighing 6,500 lb. were ordered shipped to the job. Two 10-ton tractors were brought overland a distance of 100 miles. A small camp was equipped and the work was soon under-way.

The road surface was first scarified. The grader followed the scarifier and kept the gravel spread around so that the laborers coming after the machines could pick the oversize out and throw it aside. When this was done, the grader man reshaped the surfacing, and then the shoulders were built up and widened with the blade where necessary. After this process was completed, it was necessary to go back frequently and blade the surfacing to keep it smooth under the traffic. It was found that a section not more than a mile in length could be torn up to good advantage at one time. Sections longer than this would compact under the traffic before the oversize could be thrown out.

Two Ford trucks were also kept on the job and used for transporting men and supplies, and also for patching the surfacing and rip-rapping and repairing small washes in the road-bed.

After the work with the tractor and the trucks was completed, the bridges were painted and given slight repairs, and a team crew went over the work and made one grade raise and widened the road-bed in places where the grader could not do it economically. A number of ditches and dikes were also repaired.

Organization and Wages of Working Force.—The crew consisted of a superintendent or foreman, two tractor drivers, two grader men, two truck drivers, one scarifier man and from 10 to 15 laborers.

The rates of pay were as follows:

1 Superintendent	$150.00 per month
2 Tractor drivers	4.00 per day
1 Graderman	4.50 per day
1 Graderman	4.00 per day
1 Truck Driver	4.00 per day
1 Truck Driver	3.00 per day
1 Scarifier Man	3.50 per day
Laborers	2.75 per day

The rates of pay were based on a 9-hour day.

The crew was divided into four parts: scarifying, blading, raking, and general repair. The scarifying crew consisted of a tractor driver and a scarifier man and were equipped with a 10-ton caterpillar tractor and a scarifier weighing 6,500 lb. and cutting 28 in. The blading crew consisted of a tractor driver, and two grader men. They were equipped with a 10-ton caterpillar tractor and one 10-ft. and one 7¼-ft. grader and a large float drag.

The raking crew was made up of laborers who raked the oversize rock from the gravel and off to the back side of the side ditches. They were assigned a Ford truck for driving back and forth to camp. The truck driver acted as sub-foreman of this crew.

The repair crew consisted of a few men and a Ford truck. Small washes were filled in and rip rap placed. This crew also hauled gravel for the surfacing when it was necessary. No attempt was made to repair large washes where teams could be used to advantage. There was only one or two places of this kind and these were repaired later, the cost of which was not taken into consideration in this article. The blading crew widened the fills in many places and did considerable work on the roadbed proper. The charges for the work and reshaping the surfacing were all included under the heading of blading.

All equipment used was owned by the state and no rentals were charged to the job with the exception of the two Ford trucks for which a rental of $25 per month each was charged for a period of about four months.

The two tractors were surplus war equipment. The scarifier and one grader were purchased new but no rental is charged by the state for that class of equipment.

Gasoline cost approximately 25 ct. per gallon and lubricating oil 80 ct. per gallon. In the miscellaneous items is one charge of $89.01 for minor repairs such as bolts, wrenches and blacksmith charges. The other miscellaneous items were rentals, rakes, telegrams, etc. Repairs for the graders consisted almost entirely of new blades.

There are 155 lin. ft. of wooden bridge on the project. The handrail and outside stringers were given one coat of paint.

Costs.—The actual cost of scarifying, reshaping the grade, removing over-size and making minor repairs on roadbed and surfacing was $7,317 or an average of $219.08 per mile. In addition to this there was an expenditure of $386.20 for moving equipment to the job and setting up camp; also $938.59 for team work in raising and surfacing 1,000 ft. of grade and making a number of major repairs on the road bed. The detailed cost of the grading and reshaping is as follows:

	Scarifying	Blading	Removing Oversize Rock	Repairing Washouts	Repair- and Painting Bridges
Superintendence	$ 186.00	$ 247.00	$ 322.00	$ 39.00	$ 4.00
Labor	700.00	996.00	1,482.00	163.00	19.00
Tractors:					
Parts	151.00	317.00	....	....	....
Gasoline	612.00	475.00	....	....	....
Oil	88.00	88.00	....	....	....
Mechanics	78.00	106.00	....	....	....
Trucks	32.00	32.00	166.00	185.00	....
Miscellaneous	289.00*	203.00**	151.00†	100.00‡	84.00§
Totals	$2,137.00	$2,465.00	$2,121.00	$487.00	$107.00
Cost per mile	$ 63.98	$ 73.80	$ 63.50	$ 14.60	$ 3.20

*Scarifier wheels, $94; 2 sets teeth, $83; sharpening teeth, $69; other items, $43.
**Grader, $100; drag, $56; other items, $37.
†Rentals, $100: other items, $51.
‡Rental $100.
§Paint, $70; Lumber, $12; other items, $2.

In this work the scarifier tractor traveled 583 miles, and the grader tractor traveled 788 miles.

The work was started Aug. 5 and completed Dec. 1. The cost of the work was greatly reduced and much better progress was made after the first two months. The mileage covered each month and the cost per mile was as follows:

Month	Mileage	Average Cost per Mile
August	5.0	$365.27
September	7.4	267.41
October	10.0	164.96
November	11.0	169.31

We are indebted to W. R. Eccles, District Engineer State Highway Department of New Mexico, for the information on which this article is based.

Paving Brick Production in June

Increases in production, shipments and unfilled orders with a corresponding decline in stock-on-hand is reported by the paving brick industry to the United States Department of Commerce for June as compared with May.

Production went from 21,103,000 in May to to 26,342,000 in June. Shipments went from 22,645,000 in May to 30,312,000 in June. Stock fell from 123,808,000 in May to 115,971,000 in June. Unfilled orders climbed from 71,430,000 to the first day of May to 75,283,000 the first day of June.

These figures are compiled from the reports of 26 companies representing 76 per cent of the normal tonnage of the industry.

Ohio lead the list in consumption for June with 8,685,000. Kansas was next with 3,700,000, Texas third with 3,198,000 and Illinois fourth with 2,446,000.

The Development of Improved Highways

A Brief History of the Growth of the Highway System of the United States Given in a Paper Presented April 21 at Annual Convocation of Western Society of Engineers

By THOS. H. MACDONALD and H. S. FAIRBANK
Chief of Bureau; Highway Engineer, U. S. Bureau of Public Roads

Of the 3,002,916 miles of highways of all classes in the United States, approximately 468,000 miles were improved with some form of surfacing at the colse of the year 1924, according to the best available estimates. If the last year's work has been as productive as that of 1924—and there is every reason to believe that it has been—the surfaced roads at present aggregate not far from 500,000 miles, about one-sixth of the total mileage.

Accepting the latter figures as reasonably representative of the present condition, it will be convenient hereafter to deal with the more exact figures of 1924, especially since surveys made by the Office of Public Roads in 1904 and 1914 furnish the statistical basis for the determination of the character and extent of the progress made during the last two decades.

According to these surveys there were 257,291 miles of surfaced roads in 1914, and 153,662 miles in 1904. The net increase during the first of the two decades was, therefore, a little over 100,000 miles, or approximately 10,000 miles a year; and this rate was more than doubled during the second and last decade.

Relative Progress 1904 to 1924.—The relative progress made during these two 10-year periods, however, is not expressed fully by the net increase in surfaced mileage. It is safe to say that practically all of the roads that were surfaced in 1904 have since been resurfaced, and undoubtedly a considerable percentage of the 257,291 miles surfaced in 1914 has also been replaced with new, better, and wider surfaces since that date. The real measure of the progress made during the last decade is, therefore, not the net increase of more than 211,000 miles but a figure which much more nearly approaches the total of improved mileage at the close of the period.

The true extent of the change becomes apparent when we examine the character of the roads classified at the three survey periods. Of the 153,662 miles surfaced in 1904 only 141 miles, or less than one-tenth of one per cent of the total, was improved with a surface better than waterbound macadam. By 1914 the mileage of this class of roads has increased to 14,830, or 5.8 per cent of the total mileage then surfaced; but more than two-thirds of the roads so classed were surfaced with bituminous macadam and surface-treated waterbound macadam, the least durable of the types included in the class. The increase in the mileage of high types to a total of 89,711 miles between 1914 and 1924 is, therefore, more remarkable in view of the fact that the surface-treated and bituminous macadam roads constituted in the latter year less than half of the total mileage of the class, which as a whole represented more than 19 per cent of the total surfaced mileage. More than 45,000 miles in 1924 were paved with concrete, brick, bituminous concrete or equivalent types; and the average width and strength of all surfaces included in the high-type class were doubtless considerably greater than in the earlier years.

Changes in Surfaces.—In 1904 there were 38,622 miles of waterbound macadam roads—practically 25 per cent of the total surfaced mileage. By 1914 the mileage of this type had increased to 64,898, but the percentage of the total mileage remained practically unchanged at 25 per cent; and in the last decade both the mileage and the percentage diminished, the former to 60,235 miles and the latter to 12.9 per cent, a relative decrease of nearly 50 per cent.

In all three years the roads surfaced with gravel and other low types of surfaces constituted the bulk of the surfaced mileage, but whereas in 1904 they constituted practically three-quarters of the total, in 1924 they represented only a little more than two-thirds. The mileage of these types in 1904 was 114,899; in 1914 it was 177,563; and 1924 there were 317,960 miles.

These changes in the character of the surfaced mileage during the two decades are shown clearly in the following table:

Class of Surface	1904 Miles	1904 Per cent	1914 Miles	1914 Per cent	1924 Miles	1924 Per cent
Gravel and other low types	114,899	74.7	177,563	69.1	317.960	67.9
Waterbound macadam	38,622	25.2	64,898	25.1	60,235	12.9
Surfaces better than waterbound macadam	141	0.1	14,830	5.8	89,711	19.2
Total	153,662	100.0	257,291	100.0	467,906	100.0

Types in 1904.—The year marks the end of a period. Up to that time there had been no important change in the methods of road construction which had been employed for a century or more. The major types of surfacing were gravel and macadam, and either was known to give entire satisfaction under the traffic normal to the country roads of the time. Other types had been developed and used in small mileage, such as the shell roads of the tidewater States and the sandclay roads of the South, but the element of availability was the determining factor in the choice of such materials rather than any difference in the demands of traffic; and the same element, in fact, largely determined the choice of the two major types.

Thus we find that there was a preponderance of gravel roads in Michigan, Indiana, Illinois, Iowa, Wisconsin, Minnesota and the Dakotas where gravel deposits were plentiful; and a preference for stone in Kentucky, West Virginia and others where suitable gravels were scarce. From New Jersey south, the Atlantic and Gulf States had built rather considerable mileages of oyster shell roads; and the Southern States in which there was a scarcity of other materials, had developed the sand-clay type. Even the small mileage of high-type surfaces which had been constructed was doubtless attributable less to traffic demands than to the availability of the materials, for of the total of 141 miles we find that 123 were paved with brick, and 104 were in the two States of Ohio and West Virginia where brick was cheap and perhaps the most available local material.

Viewed broadly the few types of surface constructed up to this time may all be considered as of one class. In the construction of all the same principles governed; in all a fragmental mass was bound together more or less firmly by a natural cement in the manner made familiar by a century of practice; and all alike depended for their efficiency upon the conic principle of pressure transmission by which they spread the vehicular loads and thus reduced the intensity of pressure borne by the subgrade.

That need was felt for no other kind of construction was due, of course, to the fact that the traffic on all roads was much the same. Even in the more populous States the greater part of the traffic using the roads consisted of relatively light horse-drawn, steel-tired vehicles, to which were added near the cities a bicycle traffic which, though it might attain considerable volume, was never more than a negligible factor in determining the type of surface. This was the normal traffic condition which existed practically up to 1904. What makes that year a turning point in highway history is the fact that about that time there began the great outpouring of motor vehicles from the cities which quickly set the intercity roads apart from others as a class requiring different treatment.

Then Came the Automobile.—The peculiar effect of the automobile on waterbound macadam roads is so well known as to require no description and the manner in which the road builders met the challenge by substituting tars and asphalts for the weaker mineral binders has been an oft-told tale. First as dust layers then as protective surface coatings, then as binders introduced into roads of the madacam type by penetration, and finally as hot admixtures according to the bituminous concrete principle, these materials, borrowed from the stock in trade of the city street builder, solved the automobile problem in a manner which was apparently entirely satisfactory.

The effect of this development in the road building art is shown by comparison of the statistics of 1904 and 1914, the dates which, to all intents and purposes, mark the beginning and crest of the wave of bituminous construction. In 1904, according to the records, there were in the entire country only 18 miles of bituminous rural roads, all in the two states of Massachusetts and Ohio. By 1914 there were 10,500 miles, a mileage which was nearly three-quarters of the aggregate length of all roads of higher type than macadam. This was the high-water mark of the lower forms of the bituminous types. That it by no menas marked the end of their usefulness is indicated by the fact that 3,367 miles of the surface-treated and penetration types were built in 1924. The recession of the tide is indicated, however, by the fact that the mileage of the two types existing in 1924 was less than 50 per cent of the mileage of all types better than waterbound macadam in comparison with the 75 per cent level reached in 1914.

And Next the Motor Truck.—It is generally recognized that these two types which came into use with the development of passenger automobile traffic are especially adapted to that class of traffic. The relative decline in their use began when motor trucks in consid-

erable numbers began to appear on the rural highways; and coincidentally we find an increasing swing toward the rigid pavements of concrete and brick and bituminous concrete on a concrete base. The turning point was reached in 1914 or perhaps a year or two earlier.

The first concrete pavement was built at Bellefontaine, O., in 1893, but up to 1909 no more than 5 miles had been constructed on rural highways in the entire country. In that year approximately 4 miles were built; in 1910 about 20 miles were added, the following year 40 miles, and then the first big increase occurred in 1912 when more than 250 miles of rural highways were paved, to be followed in 1913 with 500 and in 1914 with more than 1,500 miles. At the close of the latter year there were in the entire country 2,348 miles; and 10 years later the mileage had increased to 31,146 and construction was proceeding at the rate of more than 6,000 miles a year, a rate approached by no other type better than gravel.

The more extensive use of brick, and the bituminous pavements of the mixed type on concrete base began also at about the same time and was due to the same cause—the increased use of motor trucks. In 1914 there were approximately 1,600 miles of brick pavement; in 1924 there were 4,319. In 1914 the mileage of rural highways paved with bituminous concrete or sheet asphalt was still negligible; in 1924 there were more than 9,700 miles of these types.

Change in Character of Public Demand.—The first of the two decades we have had under consideration was marked not only by the development of new types of road but also by two other changes of even greater significance. The first of these was a general increase in the radius of travel by highway occasioned by the use of the automobile; and the second—a natural result of the first—was a change in the character of the public demand for highway improvement.

In 1904 the automobile had still to prove its ability for sustained performance. Its ownership was still limited to a small and wealthy class. The popular demand for improved roads was, therefore, still predicated upon the use of the bicycle and the horse-drawn vehicle. The farmers, always conservative, were still, for the most part, either actively hostile to road improvement or lukewarm in support of it. In general their demands was for the improvement of the roads connecting their farms with the railroad shipping points or nearby towns. More positive influence was exerted by city and town merchants who sought by road improvement to extend the trading radius and business of their towns, and by the limited but influential class of motorists who longed for smoother, mud-and-dust-free roads upon which to operate their vehicles. All these influences combined at first to produce a demand for short stretches of improved roads radiating from the towns and rail shipping points. Later, as the automobile was perfected and its users became more numerous, the latter created a demand for longer, unbroken stretches of improved roads, forming a network connecting the larger towns, a claim that was resisted by the farmers who continued to favor the so-called farm-to-market type of improvement.

Farm to Market Vs Trunk Line.—In the smaller Eastern States the conflict never became acute, largely because the distance between towns and market points was so short that the farm-to-market plan of improvement when carried to its ultimate development became practically identical with the inter-town or trunk-line plan. Thus we find the issue satisfactorily settled in Rhode Island as early as 1902 by the adoption of a definite system of State highways for construction by the State Board of Public Roads. A similar proposal by the highway commissioner of Connecticut, made originally in 1906, was enacted into law by the State legislature in 1913; and in the meantime Maryland had settled the question definitely by the adoption of an inter-county seat trunk-line system to be improved and maintained in its entirety with State funds under the State Roads Commission. Maryland's system was designated in 1908, and was the first to be placed completely under state control for both construction and maintenance.

That the controversy was not so quickly settled in many of the other states was due mainly to two reasons. First, the important lines of travel in a number of the states were not sharply defined. This resulted in some from sparsity of settlement, and in others from the contrary condition of close settlement with numerous centers of more or less uniform size and importance. States such as Texas and Wyoming were typical of the first group. In them the long distances between centers and the condition of the roads delayed the development of highway traffic between the towns and promoted a use of the highways largely as feeders to the rail lines; and the same remoteness of the towns one from another prevented the early harmonizing of the two plans of development as in the smaller Eastern States by the evolution of one into the other. Of the second class there were such states as Iowa, Kansas and Wisconsin in which the very number and uniform size of the town centers caused a diffusion of traffic over many roads and delayed the recognition of routes of outstanding importance. In these

States also the towns are essentially agricultural centers and this fact contributed further strength to the demand for farm-to-market roads as opposed to trunk lines.

The instances mentioned furnished examples of one of the reasons for the prolongation of the controversy which raged over the question of farm-to-market vs. trunk-line development. The second reason was simply that many of those states as yet had no state agency for the administration of a highway plan of state-wide scope, and the development of the trunk-line plan naturally presupposes the existence of such an agency.

The Beginning of Federal Aid.—The second of these reasons was promptly removed after the passage of the Federal aid road act in 1916 by the provision of that act requiring the creation of adequate highway departments in all states as a condition precedent to participation in the benefits of the Federal aid. And a first step toward the ultimate settlement of the trunk-line question in all States was made when the Bureau of Public Roads as one of its first administrative acts requested of all States the submission of a 5-year program map showing the system of roads upon which the State highway departments would request Federal aid during the period covered by the appropriations provided by the first act of Congress. Although the systems designated in response to this request were understood to be merely tentative the request of the Bureau had the effect of directing attention—in many States for the first time—to the desirability of establishing a definite program for the improvement of a system of highways as distinguished from the more or less casual improvement of unrelated sections of roads.

The Effect of the War.—The Federal-aid work had scarcely begun, however, when the world war intervened and practically put a stop to all operations; and the war did a number of other things to the existing improved roads which, however disastrous they may have appeared have turned out to be a blessing in disguise. At the outset the construction and maintenance of highways were declared to constitute a non-essential industry. As a consequence new construction, except as required for the immediate service of the army, was greatly curtailed. This result is reflected in the records which show in 1916—the year before American's entrance—a construction of new roads under the supervision of the State highway departments amounting to 16,160 miles; a decline to 11,996 and 11,944 miles respectively in 1917 and 1918; and a return to 18,260 miles in 1919. Maintenance also was greatly hampered by the difficulty of obtaining the necessary materials and the scarcity and high wages of labor. At the same time there was released upon roads generally inadequate to stand it an unprecedented traffic of heavy motor trucks. To this experience and the heavy damage which followed we owe the development of most of the sound principles and policies which now govern the improvement of highways.

The first result was a strong reaction against the use of heavy motor trucks. There were large numbers of people who, forgetting that a road is of service only in so far as it accommodates the need for economical transportation, demanded that the manufacture and operation of vehicles too heavy for the existing roads be prohibited. As few of the roads were designed to carry motor truck traffic to have taken this course would have amounted to the throttling of a new development in transportation before it had a chance to demonstrate its utility, and it was rightly opposed with great energy by the manufacturers of motor vehicles. The latter, on the other hand, took a position at the opposite extreme from which they demanded the right to manufacture and sell vehicles of large capacity and heavy weight, without regard to the strength of the roads, on the theory that the greater capacity of the vehicle the smaller would be the cost of operation per unit of capacity. Their slogan was, "build the roads to carry loads," and this was met by the opposite party with the equally dogmatic demand that the loads should be limited to the capacity of the existing roads.

The issue thus joined, the principals to the controversy—highway officials on the one side and the manufacturers on the other—wisely agreed to submit their differences to the test of mutual discussion; and out of the series of conferences which ensued there came an agreement upon certain fundamental facts and principles which have served as the basis for a harmonious co-operation of the two groups, and which now constitute the foundations of highway improvement policy in all States.

Vehicle Weight As Critical Faction in Design.—It was agreed at the outset that for the first time in history the weight of vehicles had become a critical factor in rural highway design. Hitherto the minimum practical thickness of road metal had been sufficient to carry the maximum vehicular load. The development of the motor truck had altered this situation. It called for stronger surfaces that would spread its heavier load over a wider area of the subgrade in order to reduce the intensity of the pressure to an amount which the soil could support.

It was clear also that whereas deterioration of the highways had previously resulted mainly from the attrition of the surface, a new form of deterioration approaching rapid de-

struction would result unless the roads upon which the heavier motor trucks were being operated were strengthened so as to enable them to carry the increased weights. And whereas, the amount of the deterioration had formerly been a function of the volume of the traffic and of time, the new destruction by excessive weight might be caused by a few vehicles in a very short time.

It was agreed, therefore, that the highway officials must have definite knowledge of the maximum weight to be supported as a first condition of design; and this knowledge was supplied, in a measure, by the voluntary decision of the manufacturers to limit to 7½ tons capacity the future production of vehicles. Engineers were thus assured that if, in the reconstruction of the thoroughfares upon which heavy trucking had developed, they would design to accommodate a vehicle of 7½ tons capacity that would not see their handiwork quickly destroyed by vehicles of much greater size and weight.

Recognition of True Cost of Highway Transportation—But this alone was not a sufficient basis for the design of all roads. The building of roads of sufficient strength to carry 7½-ton trucks required a heavy investment of public funds, which could be justified only if the economics inherent in the transportation of goods in vehicles of large capacity were sufficient to outweigh the increased cost of the roads. It was recognized clearly for the first time that the cost of highway transportation is made up of the cost of the highways and the cost of operating the vehicles over the highways, and it was agreed that the common purpose of the public highway officials, vehicle manufacturers and operators should be to reduce the total cost of transportation rather than one or the other of the elemental costs. It could be proved that the number of large-capacity trucks already using some of the highways,—principally those radiating from and connecting the larger cities—had already grown to the point where the combined savings in operating cost would more than balance the greater cost of providing highway service for them. As to these highways there could be little doubt of the wisdom and economy of building a type of surface adequate for the heavy truck traffic. Other roads, similarly located with respect to cities, had not yet developed a sufficient amount of the heavy traffic to repay the additional cost of the stronger construction, but it was not difficult to foresee that such a condition would develop in the future. On the majority of the roads, however, the development of traffic of sufficient weight to justify the higher types of construction was very remote; and it was apparent that the one-time prevailing condition of uniformity of traffic on all roads had been definitely broken down. Instead, a new and much different condition had arisen under which the main inter-city roads were found to be carrying traffic far in excess of the much greater mileage of local roads.

Under the new condition the economic justification for the improvement of the main roads lay to a far greater extent than formerly in the reduction of transportation costs and to a lesser degree in the effect upon the value of property. The main roads had become through traffic arteries, as distinguished from the more numerous local roads which continued to be of value primarily through the service they render in giving access to the land.

Density of Traffic as Factor.—As to the main roads, which carried a wide-ranging traffic, it was now clearly apparent that the character of their improvement must be commensurate with the density of their traffic; that continuity of improvement was of the highest importance; and that the traffic was already so great that the loss in operation of vehicles in the absence or road improvement would exceed the cost of improvement. These roads also were distinguished in one other respect, namely, that their traffic tended to increase far more rapidly than that which was to be found on the local roads, the condition of which remained much as it had been. Where the main roads carried long distance traffic, the local roads served the traffic of a neighborhood; where the main roads were collectors of traffic, the local roads were feeders and distributors; where the traffic of the main roads tended to grow in direct proportion to the growing use of motor vehicles and the growing resort of industry and the entire people of highway transportation, the local roads served the much lighter, and, from the standpoint of growth, far more stable traffic producer by a single agricultural community.

It became apparent, therefore, that the economic justification of local road improvement would continue to rest largely in the value and importance of the land that, in the main, the traffic would demand only a low type of improvement; and that continuity of the improvement was not so essential as in the case of the main, through roads.

Continuity in Improvement of Main Roads.—The need of continuity in the improvement of the main roads was the first of the new conditions to be met with appropriate action. From 1915 on, all States in rapid succession designated systems of State roads, including generally the main inter-city roads, to be improved under the more or less direct supervision of the State highway departments; and the several State systems were substantially

welded into a national network by the designation, in 1921 of the Federal-aid highway system which, though not quite coextensive with the State systems is practically coincident with them throughout its extent.

Continuity of improvement of the main roads thus assured it remained for a joint committee representing the American Association of State Highway Officials and the National Automobile Chamber of Commerce to enunciate a policy with respect to the rate and manner of the improvement which could win general support and adoption.

Briefly that policy may be stated as follows: It is accepted as a truism that the volume of traffic on the main roads is so great that the economics in transportation effected by road improvement clearly outweigh the cost of the improvement. This being true the improvement should proceed as rapidly as available supplies of labor and material will permit and without other limit.

The Stage Construction Plan.—All roads should be improved to the degree justified by the operating savings that may be expected to accrue to the traffic, and no road should be improved to any greater degree. Where the mileage of road to be improved is so great that the type of improvement indicated by the traffic cannot be completed on the whole mileage within a short period the most important sections should be raised immediately to ultimate type, and the balance of the mileage should be advanced through the initial stages of grading, draining, and low-type surfacing in order to spread as much of the benefit of improvement as quickly as possible over the entire road system, further improvement to await the completion of the first stage over the whole system.

This is the practice known as stage-construction, and it is the only feasible practice in the numerous States in which a large mileage of main roads remains to be improved in the face of a traffic already highly developed. It is also the logical plan of development for the main roads of the States in which traffic has not yet grown to the proportions justifying high-type surfacing.

In any case the stage-construction plan takes account of the rapid growth of traffic, which is a characteristic especially of the main roads, by providing fully in the initial stage for the subsequent construction. Grades and alignment are designed to meet ultimate requirements; drainage structures are built of durable materials; rights-of-way of ample width for the future are obtained; and the initial surfacing becomes the sub-base of the second-stage surfacing. Obviously the soundness of the plan is contingent upon the complete and continuous maintenance of each stage of the construction, a kind of maintenance which—thanks to the war experience and the standard established by the Federal Highway Act—practically all States are now prepared to give.

The accepted policy contemplates the improvement of the main roads, to which the above methods are applicable, as a responsibility of the states to be assumed through the agency of the State highway departments, and financed, in large measure, by the revenues derived from the taxation of vehicles and motor fuel. The local roads are viewed as the responsibility of the counties and lesser sub-divisions. With a few important exceptions, as in the case of Cook County and the vicinity of other large cities, the degree of improvement required does not rise above the lower types of surfacing, the expense of which may be met, as it should be by taxation of the local land and property.

Outstanding Developments in Post-War Period.—These, then, are the outstanding developments in highway improvement of the post-war period: The classification of highways according to traffic density; the designation of State highway systems in all States, the systems including the heavy-traffic highways of State-wide importance; the interconnection of the State systems by means of the Federal-aid system; the improvement of roads in accordance with traffic demands to the limit set by probable operating savings; the stage-construction plan of progressive improvement of entire system; and the development of adequate maintenance provisions. In the main, all are outgrowths of the war experience fostered by Federal aid.

The Application of Scientific Research.—One other great advance has characterized this period—the application of scientific research to the problem of developing types of construction and methods of administration and finance adequate to meet the demands of the fast-growing traffic. In this also the initial impulse came from the Federal government, and, in cooperation with State highway departments and universities, it is continuing to support numerous studies in several fields, as a result of which there is being built up gradually the structure of a new science—the science of highway engineering.

The investigations include studies of the characteristics of materials—sand, stone, gravel, bituminous materials, cement, concrete, and brick; determination of the forces applied to road surfaces by standing and moving vehicles; of stresses developed in the structure of roads and bridges by live loads, and by temperature and other natural causes; analyses of subgrade soils and tests of methods designed for their improvement; studies of the

flow of water through drainage structures, of the run-off from drainage areas, of the effect of moisture on soils, and many others of fundamental importance and value.

Popular interest has centered upon the large scale tests such as those of the Bates Road, for which entire credit is due the Illinois department, the Pittsburg (Calif.) experiments, the impact tests at Arlington, Va., and the intensive studies of highway traffic conducted by the Bureau of Public Roads in cooperation with the authorities of Connecticut, Maine, Pennsylvania, Ohio, California, Tennessee, and Cook County, Ill.

Much that is of immediate practical benefit has already been derived from these investigations; but, for the most part, they are dedicated to the future.

It is not to be expected that their fullest benefits shall be immediately realized. The building of a science is a laborious, a painstaking process, and we are still but laying the groundwork which is not much further advanced than were the foundations of the modern science of medicine and surgery 50 years ago. If 50 years hence the science of highway engineering has been built up to the point now attained by the physicians and surgeons this effort we are now putting forth will be abundantly repaid, and not too late. For the improvement of highways in the United States is a process which must be continued indefinitely.

No Slowing Up of Highway Improvement.—It is idle to talk of completion when of the 3,000,000 miles of our highways less than a fourth has been graded, but a sixth has been surfaced, and a sixtieth paved; when little more than half the mileage of the main state roads has been improved with any kind of surfacing, and there remain on these important arteries thousands of unsubstantial one-way bridges and dangerous railroad grade crossings; when the number of motor vehicles registered is doubling every fifth year and the traffic with them; when the size of our cities, and the magnitude of our industries, and the amount of our material wealth are increasing at an almost unprecedented rate. So long as these conditions continue we shall continue to build and maintain and rebuild our roads.

At the present rate we are surfacing approximately 40,000 miles a year and our annual expenditure approximates a billion dollars. There is no indication of an early reduction in these rates of construction or expenditure, dwarfed as they are by the annual production of a 1,000-mile procession of motor vehicles and an annual expenditure for operation approaching ten billions. As a nation we have set our hand to the economic improvement of our means of highway transportation. It is not a task to be accomplished in a day. It is, and must be a continuous process. There is but one limit which may reasonably be set. It is this: No road should be improved by expenditures of public funds in excess of its earning capacity. The return to the public in the form of economic transportation is the sole measure and justification of the degree of highway improvement.

Rapid Hardening Cement Speeds Completion of Subway

The problem of maintaining railroad traffic across a subway under construction on the state highway in Yolo County was satisfactorily solved by the bridge department by the use of rapid hardening cement concrete. The structure consists of reinforced concrete abutments with a deck of structural steel I-beams encased in concrete and covered with a concrete slab.

As soon as the abutments had attained the necessary strength, the steel girders were put in place and the track supported on wooden stringers, which in turn were supported by wooden blocks placed directly on the girders. Temporary piling on which the track had been supported was then removed.

The concrete portion of the deck was poured complete, except that openings were left around all track supports. After the deck had hardened the track was supported on the finished portions and the openings filled with a rapid hardening Lumnite cement concrete. Within 36 hours, according to California Highways, it was possible to remove all temporary supports from under the rails and to replace the ballast in its permanent condition.

Four aggregates were used in all concrete as follows:

Cement—1 sack.
Sand—1.9 cu. ft.
Pea Gravel—1.4 cu. ft.
¾ in. Gravel—1.6 cu. ft.
1½ in. Gravel—1.0 cu. ft.

Water—48 to 52 lb.—which produced a slump of approximately 3 in.

The rapid hardening concrete was placed in the afternoon and ponded before leaving it for the night, and on the second morning it was possible to place the ballast on the deck. Use of rapid hardening cement reduced the curing time from four weeks to less than two days. As the job was practically completed when the track supports were removed, use of ordinary cement would have meant considerable delay to the contractor before the ballast could have been replaced.

C. M. Butts was resident engineer for the bridge department of the State Highway Commission.

A Study of Unusual Earth Road Conditions

An Investigation of the Causes of Soft Spots and Mudholes and Suggested Remedies Described in Public Roads

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Soft spots and mudholes which developed after grading in a number of earth roads in northeastern Iowa manifested such unusual characteristics both as to their behavior and their location that the writer was engaged by the state highway commission to conduct a field investigation of the causes of their occurrence.

In nearly all cases the soft places did not exist before the grading of the roads. Yet after grading they began to develop at the crest or along the slopes of nearly every cut despite the fact that ample precautions had been taken to insure adequate drainage in the customary manner.

Unlike the wet spots caused by side-hill seepage these failures are seasonal in character, breaking out only in the spring when frost begins to leave the ground and continuing to cause trouble until some time after the frost has disappeared. During this period they became saturated with confined water and are no more capable of supporting a load than deep beds of soft putty which they closely resemble. The occurrences are interspersed at frequent intervals between stretches of excellent roadway which bring them out in sharp contrast and render them all the more exasperating to the traveler. Certain other peculiarities have been observed, such as a tendency of the minor failures to shift position slightly from year to year, and the strange effect of rainfall which seems to improve their condition. The most plausible explanation of the latter phenomenon is to be sought in the temperature of spring rains, which are usually warm enough to melt the frost and open percolation channels.

Natural relief cannot be expected until the surface evaporation becomes sufficiently rapid to dry out the top 4 or 5 in. of the road, forming a hard, tough crust. This crust, when once formed is generally thick enough to distribute loads and bridge over the soft material beneath until the following spring. At no time, however, is the crust capable of supporting heavy loads without a perceptible sag similar to that of a steel rail under the wheels of a locomotive.

Clearly these soft spots constitute a problem of a special nature which requires particular treatment for its solution. The objects of the investigation were therefore (1) to discover the cause of the trouble, (2) to determine the most feasible remedy for existing failures, and (3) to find the best way of handling future improvements so as to prevent their recurrence.

So far the occurrences have been observed only in nine counties in northeastern Iowa in the vicinity of the Mississippi River. Clayton County seems to be the most seriously affected, but a number of failures have been noted in Allamakee and Dubuque Counties, and to a lesser extent the counties of Winneshiek, Fayette, Jackson, Jones, Delaware, and Clinton have also been troubled.

In Clayton County alone, the total length of the failures, in improved primary roads only, is more than 8,000 ft., and if this figure be increased in the proportion that the present improved mileage bears to the total mileage of primary and county roads in the county, it appears as probable that something like 32,000 ft. of roadbed will eventually require treatment.

Conclusions as to the Cause, Prevention, and Remedy of the Failures.—As a result of the writer's investigation, in the course of which 444 test borings from 4 to 21 ft. deep were made in roads in Clayton County, the following conclusions have been reached with respect to the cause, prevention, and remedy of the failures.

The soft spots have been found to occur almost exclusively at the crest or on the side slopes of cuts made in grading the roads, and the investigation indicates that they result from the exposure by the grading operations of unweathered, loessal clay which, in the unimproved road, was overlain by stable, weathered material. The water contributing to the condition is, in the main, of purely local origin. Underground sources of supply, such as spring or seepage veins, have, as a rule, been definitely eliminated.

For the curing of the existing failures the most practical remedy, in the opinion of the

writer, is to remove the unstable material to a depth of at least 2 ft. and replace it with well weathered topsoil or "black dirt," thus providing a stable crust to bridge over the unstable material during the critical period, and duplicating the condition known to exist at places where no failure has occurred. Several other remedies have been proposed, among them the covering of the affected areas with rock or sand, the addition of lime to the soil, the use of tile drains, the planting of trees which it is hoped will remove the moisture from the soil, the burning of the unstable material, the paving of soft places, and others of a less practical character. For reasons which will later be presented the writer believes the formation of a crust of weathered earth to be the most practical procedure; but it would perhaps be wise to test a number of the proposals which seem to be feasible with a view of adopting the one which proves to be the most effective and economical.

For roads to be graded in the future two methods are proposed in order to prevent the creation of the faulty condition: Either, (1) adjust the grade line to avoid cutting the hills by making heavy fills with borrowed earth; or (2) balance the cuts and fills in the usual way by making allowance for the extra depth of excavation in cuts necessary to provide for replacement of unstable material with weathered soil.

Extent and Procedure of the Investigation.—The evidence necessary for the determination of the cause and character of the failures was obtained by boring test holes to reveal the nature and thickness of the various strata.

The first test hole was dug at station 875+00 of primary road Nos. 10-13, about 1.5 miles southwest of McGregor from which a continuous line of borings were extended to a point near Elkader at station 165+00. Two hundred and sixty borings were made in this section of graded highway, each of which penetrated the loessal deposit and extended into the till or residual soils beneath. For the most part, the holes were dug on the left shoulder of the road about 8 ft. from the center line and the usual depth was from 10 to 15 ft., extreme variations being from 4 to 21 ft. The diameter of all the holes was 6 in. and the spacing in all cuts was from 50 to 100 ft. or closer. A number of holes were also dug in the stable portions of the road, and a few were located in adjoining fields. At the time of making each boring depth measurements were taken and every change in color, texture or consistency of the soil was recorded.

The station number of each hole was accurately determined from the permanent reference hubs and a continuous line of levels was run to establish the elevation of the road surface at the holes. The elevation of the top of both banks opposite each hole was also obtained so that original surface elevations could be computed.

In this way every cut in the McGregor-Elkader road was thoroughly investigated and an attempt was made to account for those that had not caused trouble as well as for those that had. The failures of 1925 which,

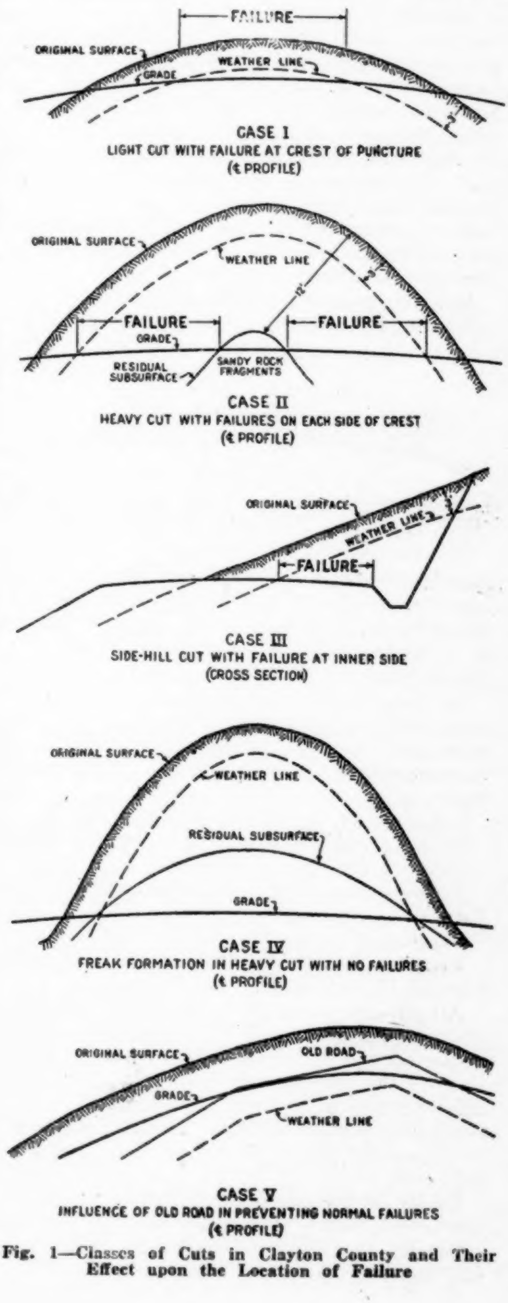


Fig. 1—Classes of Cuts in Clayton County and Their Effect upon the Location of Failure

on this section of highway, aggregate 3,933 ft. in length, were identified by laths driven in each bank opposite their extremities, and wherever such a stake was found its station number was recorded and used to locate the borings. A few unstaked failures were located from the records of County Engineer Hahn.

The next stage of the investigation consisted in boring all the proposed cuts in primary road Nos. 19-20 from Postville to Monona, at present unimproved, though the plans for such improvement are complete. One hundred and forty-six holes were sunk in the manner already described except that in this road many of the borings were made along the center line in relocations. When the notes of these borings have been plotted, it should be possible to predict with a fair degree of accuracy the location of the failures that may develop after construction.

For the purpose of securing corroborative evidence, 41 holes were bored, covering the

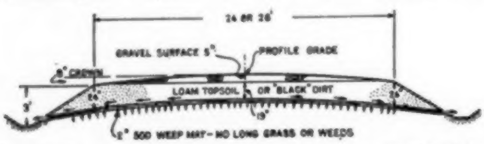


Fig. 2—Essential Features of Top Soil or Black Dirt Treatment. Any Existing Tile Lines Should Be Excavated and Relaid in Black Dirt

eight failures between the intersection of primary roads 10-13 and 19-20 and Monona. These failures, which have an aggregate length of 1,939 ft., were obtained from County Engineer Hahn.

In order to make certain that the soil conditions revealed by the continuous lines of boring were truly typical, the writer conducted brief reconnaissance examinations of the following roads:

Primary No. 51—Postville to Waukon.
Primary No. 19—Postville to West Union.
Primary No. 56—West Union to Elkader.
Primary Nos. 10-13—Elkader to Strawberry Point.
Primary No. 56—Elkader to Garnavillo.
Primary No. 20—Intersection of primary Nos. 10-13 to Guttenberg.

All cuts on these roads, including a number of treated and untreated failures, were closely inspected and sufficient borings were made to identify the various strata as belonging to the classification previously established from the continuous lines of borings. Nothing was found to controvert any of the conclusions previously indicated.

Cause of Failure.—Early in the process of the investigation it became evident that the difference in elevation between the road grade and the original ground surface was the key to the situation and not the depth of cut below the old road, unless the two happened to coincide. Proceeding on this premise, the cause is to be sought in the geological and soil characteristics of the area affected.

Without going into an extended discussion of geologic history, this region may be said to lie in a position untouched by the last glacial invasion. Consequently it is blanketed by a layer of fine-grained, loessal clay (presumably of wind-blown origin) which covers the tough sandy clays laid down in a previous glacial epoch of residual soils composed of weathered rocks. These underlying clays though stiff and gummy and mixed with sand and angular rock fragments which render them permeable and firm. In color they range from a deep, ox-blood red to pale tan and wherever exposed, provide an excellent roadbed.

The overlying blanket of loessal clay on the other hand, never contains any sand or rock fragments and, in general, presents opposite characteristics. Its usual thickness is from 9 to 15 ft. and, though somewhat thicker on hills, as a rule it conforms closely to the residual subsurface. In its undisturbed state, three degress of weathering are clearly marked.

Starting at the bottom (on the residual subsurface) the first stage is noted as a pure, bright, gray clay interspersed but not mixed with thin laminated streaks of dark brown and yellow oxides and carbonates of iron (limonite striations). This clay, though fine grained, is rather stiff and requires considerable pressure to work in the hands. Its consistency in place is generally that of stiff putty, but, when dry it is powdery and fluffy, like flour. In some instances, where it overlies colored sandstone, a thin layer at the bottom of the stratum is found to be discolored to chocolate-brown, mouse-gray or ink-blue.

In the second stage, immediately above the first, a dull, drab gray occurs mixed with nodules of brown and yellow limonite, which has been partially oxidized. The mixing process is not so pronounced near the bottom of the layer but it gradually increases toward the top, until, in the uppermost portion, the mixture is so well mottled that its component parts are difficult to detect. In its natural condition, the clay in this stage is generally quite wet, ranging in consistency from very soft to soft putty, and occasionally stiff putty. When worked in the hands it is very soft, yielding, sticky and plastic.

The third and last stage represents a stratum of the same mixture in an advanced stage of oxidation lying near the ground surface. It is no longer possible to discern particles of limonite nor is any of the gray clay visible. The product of complete weathering is a fine-

grained clay of even texture and uniform color, ranging from a light buff-brown at the bottom of the stratum to a darker brown cast near the top. In fields, the top 18 in. or more is permeated with humus and decayed vegetation, which is responsible for the dark color, and its familiar name is "black dirt."

Piercing of Weather Line Causes Soft Spots.—Before considering consistency, it is well to divide this upper stratum into two parts: (1) Stable; and (2) unstable. One can never be certain just exactly where this line should be drawn, even while making borings, but perhaps three-fourths the stratum thickness below the surface would not be far from right in a majority of cases. Above this line oxidation is complete, the soil is thoroughly weathered, dark in color, crisp, firm, friable and crumbly, and is normally moist or quite dry. Below it,

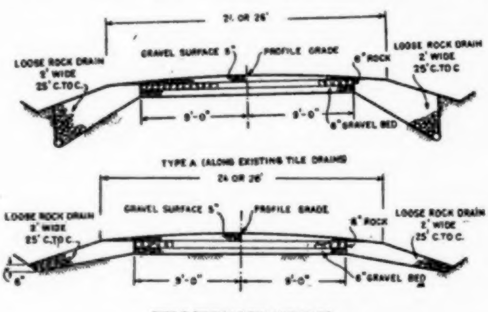


Fig. 3—Rock and Gravel Surface Treatments Shown on the Plans of the Iowa State Highway Commission

the color is lighter brown, the texture gummy and unyielding, and the consistency is generally that of stiff putty. Obviously, this line represents a critical elevation, since cuts that either pierce it or approach it too closely are almost certain to cause trouble. Hereafter, it will be designated and referred to as the "weather line." Above it complete weathering has occurred and conditions are stable. Below, and between it and the residual clay line, unstable conidtions are found since the soil is in various transitional stages of oxidation, the latter process probably progressing in increasing degree fram bottom to top.

Practically no difference can be detected, chemically, between the stable and unstable conditions, but the collodial content of the unweathered portion is doubtless very high.

The entire depth of the loessal deposit as well as the thickness of layers in any one of the three stages of weathering can naturally be expected to vary considerably in different localities. However, 12 ft. can be said to be the most common depth with the intermediate layers spaced proportionately. On this basis, a typical section may be described as follows: Total thickness of deposit, 12 ft.; thickness of first stage, 4 ft.; thickness of second stage, 4 ft.; thickness of third stage, 4 ft. The weather line in this case would be three-fourths the thickness of the third stage or 3 ft. below the ground surface.

All the foregoing discussion has been confined to soils in their original or natural state. The situation existing in failures on graded roads cannot be so simply defined. Here, the normal processes of oxidation have been interefered with and the three degrees of weathering are not so clearly apparent. If the cut is deep enough to remove the third stage and sufficient time has elapsed to allow partial oxidation of the first stage, only soils in the second stage of weathering may be present. In time, these soils would no doubt gradually become further oxidized and finally pass into a stable condition, but it would be futile to hazard a guess as to the number of years required. The churning and kneading action of traffic also complicates the classification by producing an unnatural mixture at the road surface.

As long as surplus water is kept away from the upper 2 ft. of this material it forms a firm roadbed with a tough, rubbery crust. Once it becomes saturated, however (and its affinity for capillary moisture is very great), the water clings tenaciously and whatever structure it may have possessed is immediately broken up. In this condition it is extremely soft, sticky and plastic, and shifts about readily under traffic. If enough water is present it can be made to flow like thick molasses.

The only time when such a condition occurs naturally is in the spring of the year when frost is going out of the ground and large quantities of water are drawn from the wet layers beneath by capillary action. At this time, downward movement of excess water is shut off by frost and escape into side ditches is prevented by frosty, plastic shoulders. If tile drains are present, the chances are they lie in a bed of the same material which has flowed over and effectually sealed the joints. About the only way in which surplus water can be removed, then, is by evaporation which, at this season, is very slow. Relief cannot come until all frost is gone and the opportunity for vertical and lateral percolation is presented.

Source of Water.—Nothing was more clearly demonstrated in the investigation than that water is not delivered under pressure from underground sources, either as springs or seepage veins. The water is purely of local origin and is held permanently at considerable depths by the peculiar capillary properties of the soil in question. In only a few instances was flowing water encountered and these were in

localities remote from failures at depths that could cause no trouble.

In most of the test holes, a layer similar to soft putty was struck at a depth of 6 to 8 ft. and this extended, as a rule, to 12 ft. Below this point the material seemed to become drier. The reisdual sandy clays were, for the most part, relatively dry. This leads to the belief that there exists permanently, somewhere between the ground surface and the residual sub-surface, a layer of saturated material which dries out slowly by percolation from below and evaporation from above. Local rains, of course, continually replenish the moisture removed in this way. The only effect of a long, hot dry summer would be to reduce the thickness of the saturated layer.

In a few places, the roots of large trees had extracted nearly all the surplus water and wherever this had occurred, borings showed the soil to be quite dry or merely damp all the way down. Other places were noted, however, where the effect of trees was not so pronounced. Strange as it may seem, the soil, in midsummer is noticeably drier in the failures than in any other part of the road. In all probability this is due to the fact that the loessal blanket is usually of minimum thickness in failures, causing a corresponding thinness in the saturated layer, which in turn produces relatively dry soil conditions because less water is held in storage.

Manner of Occurrence.—From the foregoing discussion it is plain that whenever cuts of more than 2 to 4 ft. below the ground surface are made, the danger zone is generally entered and a failure is likely to occur at the crest of the puncture. (Case I, Fig. 1.) If the cut is deep enough entirely to remove the loessal deposit and intersect the residual subsurface, failures commonly take place on either one or both sides of the crest. (Case II, Fig. 1.) In this connection, the crest of the puncture may or may not coincide with the high point of the road grade line.

Where the road lies in a steep side-hill cut, the stable material from the high side has generally been deposited in the outer half of the roadbed and soft spots normally develop in the inner half only. (Case III, Fig. 1.) Occasionally a freak formation is encountered where deep cuts, penetrating the residual subsurface, do not result in a failure on either side. (Case IV, Fig. 1.)

In other localities the improved roadbed was observed to be 3 ft. or more below the ground surface with no failure in evidence. Such a case could usually be explained by the fact that a fill or only a very light cut had been made on the old roadbed which had previously been eroded well below the original surface. The weather line, under these circumstances, had had sufficient time to penetrate perhaps, 3 or 4 ft. below the grade of the old road. (Case V, Fig. 1.)

Proposed Treatment for Improved Roads.—As remedies for existing failures, many ideas have been advanced and these will be touched upon later, but it seems to the writer that the simplest, cheapest, and most practical method would be to duplicate within the failures conditions that have been found to exist outside, beyond either extremity. This means that the unstable material now present must be entirely removed to a depth of at least 2 ft. and well-weathered topsoil or "black dirt" used to replace it. Every facility should be provided to allow the water from melting frost to escape to the side ditches without puddling at the surface.

For this purpose, the writer believes the excavation should extend entirely across the roadbed, should be given a slight crown, and should be paved with a thin layer of tough sod or grass roots (no long grass or weeds) before backfilling with topsoil. The sod would then act as an insulating layer separating the stable and unstable material and would also provide a permeable mat through which the water that rises from below could seep into the side ditches and flow away. Any organic matter like sod will naturally rot in time, but if air is excluded and the sod is kept moist, it is believed that its decomposition will proceed very slowly. Even after it has rotted out, many minute root cavities will remain and provide a permeable passageway for seepage. Such use of sod can be defended on the ground that it is always removed from the base of earth dikes and dams for the reason that it does permit easy percolation of water.

The side ditches should of course be deep enough and have suffiicent fall to assure the removal of seepage water as rapidly as it arrives. Any rain that falls during the critical period will be disposed of in the same way as in other parts of the road. Care should be taken to see that the topsoil extends well beyond the limits of the failure and that it feathers out into the stable portions of the road. One other point that commends itself in this regard is the fact that all materials necessary for the treatment are available at the site where needed. The essential features of the treatment by this method are shown graphically in Figure 2.

Two of the worst failures in the entire section were treated in this manner during the fall of 1925, and an inspection made during April showed the treated sections to be in good condition, although soft spots have developed as usual in other cuts and in the locations predicted.

Proposed Treatment for Unimproved Roads.—For roads not yet improved in this section two methods of procedure suggest themselves. Either (1) the grade line can be adjusted to avoid cutting the hills by making heavy fills with borrowed earth, or (2) cuts and fills can be balanced in the usual way by making allowance for the extra depths of excavation in cuts necessary to provide for replacement with weathered material. The writer is inclined to favor the second method since construction can be carried on in the customary way and the treatment can be provided at small additional cost; but some situations no doubt exist where the first method would be preferable. In the long run, of course, topographical conditions would determine which is the most feasible in any given case. The first method, however, does possess a real advantage in that it is not dependent on experimental support to insure its success.

Rock Treatment.—Figure 3 illustrates the method of rock treatment, suggested by Mr. Hutton, that has ben tried with considerable success in a number of failures. The chief objection to its use lies in the expense of application and the fear of some engineers that it will prove to be temporary, since water has been observed oozing up between the rocks. This or any other method would doubtless be more effective and traffic condition would be greatly improved if the unstable shoulders were entirely removed.

Sand Treatment.—The method of replacing the unstable material in failures with sand undoubtedly possesses considerable merit. Sand is heavier that "black dirt" and may make a firmer roadbed without hindering the passage of water. Its grains lack cohesion, however, and it would probably work its way down into the saturated clay and disappear (as gravel does at present) unless separated from the clay by a layer of boards or other impenetrable material. In exceptional places, where the grade line lies only a foot or so above the residual subsurface, sand dumped into the failure would effect a cure.

Lime.—The addition of large quantities of lime, well mixed with the clay, would be of considerable benefit, in breaking up its dense and gummy structure. Experiments may show that this process progresses to a sufficient extent to cause relief. It is common practice among farmers to use lime for this purpose.

Use of Tile.—There is little doubt that the benefits from tile drains as ordinarily laid in this material do not justify their cost. Even if their joints are not sealed by the plastic clay, the tile lie at such a depth as to be below the thaw line for several weeks and hence are rendered inoperative at the most critical time. After the frost has disappeared, however, they certainly would have some effect (with open joints) in reducing the amount of water present at the time of freezing in the fall.

The writer can not help but believe that a line of tile under either one or both shoulders, laid in a thick bed of "black dirt," with spurs angling into the failures at frequent intervals, might effect a cure. If used in conjunction with other methods, such tile would surely serve to produce less aggravated conditions in the spring.

Trees.—All trees, and especially some varieties such as willows, have a well-known capacity to absorb large quantities of water during the growing season. Wherever a number of trees were found during the investigation close to the right of way, their effect on the moisture content of the roadbed was noticeable, and some stretches of good road can be cited that would probably have been failures without the protecting presence of trees. Where large trees exist at the site of cuts, their presence constitutes a fortunate coincidence. To plant them, however, and then await their slow development, can hardly be seriously considered as a measure of practical relief.

Burning.—The writer has been informed on good authority that some railroad companies, owning mileage in similar soil conditions, make a practice of burning the clay to hasten oxidation and destroy its unstable properties. Briefly, the process is said to consist in stripping off the top layer, applying a hot flame to the subgrade and then replacing the surface soil in its original position. This kind of treatment would necessitate a large plant investment, would require skilled labor to operate it, and would be expensive to maintain. It might be tried in case the less expensive and more practicable methods failed to give relief.

Short Sections of Pavement.—It is said to be customary in Wisconsin to cure isolated soft spots (presumably of the same nature as those in northeastern Iowa) by constructing short sections of concrete pavement to distribute traffic loads over wider areas and thus prevent failure. This practice has many features to commend it if the necessary expense however, as to whether a permanent pavement could be easily maintained with such can be met. Some doubt would seem to exist, however, as to whether a permanent pavement could be easily maintained with such unstable material directly beneath.

Temporary expedients.—In order to avoid closing the roads altogether for several weeks in the spring, it is common practice to bridge over the failures with heavy planks, laid di-

rectly on the yielding surface. The planks are later removed and piled at some convenient point for use the following spring. This practice requires no comment other than that it can not be condoned on any but emergency grounds.

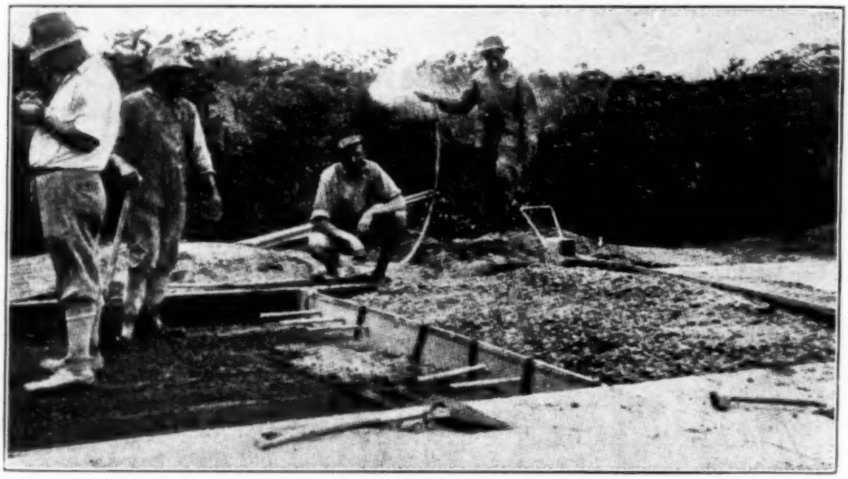
Another temporary expedient, common in the minor failures of unimproved roads, has been to corduroy the wet spots with logs and long timbers placed transversely across the road. This primitive method is of historical interest since it has been used from time immemorial to bridge any and all kinds of mud holes, and, where logs can be kept permanently wet, it is entitled to some consideration. At least it can boast the merit of cheapness.

Other Remedies.—Among the other remedies that have been proposed may be listed, (1) chemical treatment, by which the weathering process will be completed overnight through the injection of some cheap chemical compound, and (2) the introduction of sawdust, hay, manure, or other rubbish into the failures with the hope that some magic effect will be produced that can not be clearly explained. It seems hardly necessary to add that, if any such remedies should meet with success, the good fortune will be purely accidental.

Since no theory is worth much until it has been tested by actual experience, the writer is in hearty sympathy with the plan to try a number of remedies that seem most feasible, with the view of adopting the one that proves best for general recommendation and use. He believes, however, that each experimental treatment should be carefully installed, under close supervision, so as to insure a fair trial to all.

Special Joints in Concrete Road

In the construction last year of a 32 mile concrete pavement in Ocean and Burlington Counties, New Jersey, a special feature in the installing of joints was used. The construction involved the use of the bituminous poured joint and the use of metal caps over premoulded joint where that material was used. The form or core for the poured joint was a built up board having collapsible sides of corrugated cardboard with solid cardboard center. Holes were punched in the board for dowel bars. A metal cap protected the top of the joint which was placed just a shade below the elevation of the side forms. After concrete had been deposited, struck off and finished over the joint, the finisher ran an edging tool on each side of the cap before removing it. Later, when the concrete had partially set up, the inside solid cardboard of the joint was pulled out by the use of a special pair of pincers which allowed the sides to collapse, facilitating their later removal. Bituminous filler was poured into the crevice before the road was opened to traffic. The use, also of a metal cap on premoulded joint allowed finishing, both hand and machine, to proceed right over the joints and precluded the necessity of trimming the material after the pavement was completed. It has an added advantage in that the cap holds the top of the filler straight and results in a cleaner-looking joint. Expansion joints which extended continuously through the two 10-ft. strips were spaced at intervals of 45 ft.



Special Type of Joint on Shore Road in New Jersey

Securing Rights of Way

Some of the Problems in Michigan Described in Michigan Roads and Pavements

By PAUL H. REYNOLDS

Right of Way Engineer, Michigan State Highway Department

The class of property which we are interested in can be divided into two groups.

First, agricultural lands. From a right-of-way angle this class is much easier to appraise and secure that the developed property.

Second, land which has been developed into residential or business property or which is ready for immediate future development.

Widening Existing Highways.—Originally our efforts were largely confined to the widening of existing highways through agricultural lands and it was not difficult to convince the average farm owner that the wider right-of-way was a real asset. Also it as a simple matter to ascertain the amount in dollars and cents which he should receive. The property owner gave up a certain amount of land which could have been used for farming purposes and this land had a definite value.

In order to establish a standard which would tend to treat all owners alike we used the assessed valuation in farm lands. If the assessed value does not equal actual value (which is usually the case) the increased value the frontage derives from the improvement more than makes up the difference. Usually the element of damage does not enter into these types of transactions and it is this damage bug-a-boo which often makes relocations difficult to secure and causes the great majority of condemnation cases. If the damages due to any change in alignment or grade are of a character so that they can be computed it is not as a rule difficult to deal with the property owner. In such a class is the cutting of fruit trees which have more or elss of a standard value, loss of a well, cost of re-arranging fences, etc. However, the intangible damages are at best only a matter of opinion and naturally the property owner is exceedingly anxious to protect himself, therefore often setting an exorbitant sum as his price for the right-of-way.

Cutting Through Farms With New Highway.—The most common case of this kind is the cutting through farms with a new highway, leaving buildings on one side and making it necessary to cross the new highway with stock. We can assume that this damage is permanent; the amount, though, varies considerably for farms of the same size and cut in the same manner. A stock farm would be damaged more than an ordinary crop-producing farm. The design and size of buildings must be considered and the possibility of selling a portion as a separate farm rather than holding the original farm intact.

Let us assume as an example that a long 80 is cut so that the back 20 acres is separated from the remaining 60 and that the buildings are on the 60. Let us also assume that this is a stock farm, that this back 20 is largely used for pasture and the farm as a whole is valued at about $100 per acre. As stated before, this factor of damage is purely one of opinion, but some idea as to the extent may be usually obtained by considering the rear 20 as a distinct unit. The question at once arises as to whether or not this 20 acres could be eliminated from the original 80 and the farm still operate economically as a 60.

In some cases this could easily be done, in others such as the one outlined above the buildings are designed for an 80 and it is essential for the property owner to have 20 acres of pasture, or else go into some other line of farming which may not be so profitable. If the 20 can be eliminated as a necessity to the 60, then the appraisal is simplified a considerable extent. Its value of $2,000 when attached to the original 80 would of course be lessened when considered as a separate unit without buildings, however, it could possibly be sold to another adjoining owner at nearly its actual value; at least it could be sold at some slight discount.

In this way, it is necessary for the purchaser of right-of-way to actually deal in real estate and all the factors regarding the effect of the relocation upon the whole property must be carefully considered. It would be very unusual for the farm above mentioned to be damaged to the value of the entire 20 acres, yet under certain conditions, necessitating the entire replanning and reorganization of the farm, it might be the case.

Often it is possible to acquire fractions of farms cut off from the buildings for about the same amount of money it would take to buy the right-of-way and of course this should always be considered and taken advantage of, however, one should not be too optimistic about obtaining even a fair market price for the land to be sold as salvage unless for some reason one can anticipate an increase in value. I believe as a general rule we cannot hope to sell farm land purchased under these conditions at more than 75 per cent of its ordinary value.

Right of Way Through Developed Property.—The purchasing of right-of-way in developed property is more complicated but at the same time values are more definitely established and the damages and benefits more real, therefore easier to compute on a strictly commercial basis.

There are four general plans to be followed in the securing of right-of-way through this class of property:

First—Donation. Where property is developed to the extent of establishing frontage values, or it is apparent that it will be in demand for development in the near future, the increased valuation of frontage due to the highway improvement ordinarily exceeds the value of the land taken. Property owners, especially real estate men, are not slow to realize this and we have been able to acquire miles of wider right-of-way in the vicinity of our larger cities by donation. Of course if the frontage is platted and the lots sold, it is impossible to expect the owners of the front lots to donate their land unless they hold enough in the rear to take advantage of the increased valuation. As this is not usually the case it is impossible to expect any great amount of donation through platted property, and practically none if the subdivision has passed out of the hands of the subdividers.

The second plan is that of purchasing the right-of-way needed outright, without dealing in any way with back tier lots. In following this plan it can easily be seen that the highest price is paid for the right-of-way and it should only be followed under very unusual conditions. The ordinary use of this plan is when the front tier lots have few or no buildings and the back tier a considerable number. Then the cost of moving the buildings and the difference between buying and selling prices would be greater than the cost of the front lots at standard value.

The third plan is advisable when the front lots have a large number of buildings and the back lots comparatively clear. Under these conditions we purchase back tier lots, move the buildings back and deed these to front lot owners in exchange for the needed right-of-way. It can be seen that this plan is ordinarily much cheaper than that of purchasing the front lots.

The fourth plan is that of acquiring both front and back tier lots but can only be used to advantage where no buildings exist. When this is done the purchaser of right-of-way gets the benefit of the increased value instead of lot owner. It has been found that back tier lots of equivalent area to duplicate front lots can be purchased for about 15 per cent of the frontage values. If both front and rear lots are acquired, frontage will only have to increase this 15 per cent for us to obtain the right-of-way at no cost.

Let us assume an ordinary city block with 7—40-ft. front lots, 100-ft. deep, valued at $100.00 per front foot; this would make a total value for frontage on this block of $28,000. The equivalent area in the rear should be purchased for about $4,200, making a total cost to acquire both front and rear of $32,200. Now if the improvement increased the values of frontage 15 per cent, the right-of-way will be obtained free. As a matter of fact we have tried this plan out successfully and find that in well-developed properties the improvement has always increased values more than 15 per cent, in some cases raising it 100 per cent.

A Psychological Truth.—One psychological truth which we have discovered in negotiating for right-of-way is this: The average property owner is not so set on how much money he is to receive, but he wants to be sure he is getting as much as his neighbor. We believe it is just as easy to acquire wider right-of-way through farm property by offering $50 per acre as it is to offer $60, providing all the owners are treated the same.

It is sometimes dangerous to establish a high rate, as demonstrated some time ago when we attempted to acquire right-of-way through a small village at what we now consider too high a rate. The property owners began to think they had something with a high value to sell and it was only possible to secure a small percentage of this frontage. Not over a month later in another village on the same road less than twenty miles away we set a value of about five per cent of that in the first town. We talked $5 to these owners where we had talked $100 before and strange as it may seem we secured 90 per cent of this frontage without any special effort leaving every one satisfied.

Tide Aids Emergency Repairs to Bridge

An 80 ft. vertical lift span timber truss bridge over Eureka Slough, at the city limits of Eureka, Calif., became unsafe for traffic, when the lower chord of one truss parted, thrusting the end posts against the towers at each end. To permit light traffic, and be able to raise the span for boats to pass thereunder, it was necessary to make quick emergency repairs. The tides were harnessed to assist with the work. A barge was floated under the truss on a rising tide, anchored in position and cribbing built up on the deck to the truss. A wedge was placed between the truss and the cribbing and as the tide raised the truss from its seat, the wedge was driven out to hold the truss at the correct elevation, while house jacks were used on the ends of the broken lower chord to force the ruptured member together at the break until splice plates were fitted in position. The work was completed on the one tide and traffic up to 5 tons permitted to use the bridge immediately. Additional strengthening of the truss is being accomplished.

Bus and Truck Regulation

What Is Being Done in Iowa Described in Paper Presented April 21 at Convocation of Western Society of Engineers

By DWIGHT LEWIS

Chairman, Iowa State Board of Railroad Commissioners

With the establishment of gravelled roads and paved roads, there appeared occasional bus lines or truck lines between some of our larger cities and smaller ones nearby. The conditions were so chaotic, service so unsatisfactory, menace to public safety so great, that the legislature in 1923 gave the Iowa railroad commission the authority to issue franchises or what were called certificates of operation to motor carrier applicants upon a showing of public convenience. There was also a tax fixed based upon tonnage at the rate of one-eighth of one cent per ton per mile when pneumatic tires were used, or one-fourth of one cent per ton per mile for vehicles with solid tires. This has been amended since and the road mile tax has been made double this figure.

The boards of supervisors of the various counties have complained bitterly that the tax provided for did not compensate for damage done to highways, and the Iowa Commission has several times recommended that careful and elaborate tests be made to determine just the measure of damage caused by these vehicles, and have the charge for the use of the highways or the tax for the use, based upon such actual figures. This has never been done and dissatisfaction still continues, the motor carrier operators declaring that this ten mile tax is too high while the county authorities in charge of highway improvement and maintenance are complaining such rates are too low.

The law of 1921 was declared unconstitutional in that it required the users of oil trucks to pay the license fee while exempting the tracks carrying farm and dairy products.

Commission Given Jurisdiction Over Rates and Service.—The legislature of 1923 sought to remedy the defects found to have existed in the previous statute and as already stated, also doubled the tax rate, gave this commission additional power including jurisdiction over rates and service, and while the former statute had made the taxes payable to the various counties in which the carriers operated, the new law provides that such taxes shall be paid direct to the railroad commission which shall retain 20 per cent. for the maintenance of the motor carrier department, the balance to be turned over to the state treasurer to be allocated to the various counties through which the motor carrier operates on the basis of miles run.

This law has also been called in question by a number of the motor carrier operators in Iowa because it only applies in its taxation features to public carriers of freight or passengers operating between fixed termini and over a regular route, complaint being made that it is special taxation and the taxes provided for are not uniformly assessed.

We have in Iowa at the present time 121 motor carriers operating 163 routes, 77 of which are passenger carrying routes aggregating 3,486 miles, while 86 are freight carrying routes aggregating 2,511 miles. These figures are approximately accurate.

Granting Certificate of Operation.—The new law provides that a certificate of operation may not issue to an applicant without a showing of public convenience and necessity, the words "and necessity" having been added to the previous requirement. There were certainly many varieties of bus and truck operators in Iowa when the first law became operative in April, 1923, and the law provided that all of those operating at that time were to receive certificates without a showing. There are still a few of these original operators but not many. Most of them were using old second hand cars and busses or trucks that were about through and when these finally collapsed there was no capital with which to continue the business.

The board now requires a showing from applicants as to character and financial responsibility in order that the public may be assured of continued service, should the commission find from the showing made that the public convenience and necessity demand the service proposed, and a higher type of operators are gradually entering the field. While it has been a veritable nightmare to attempt to bring order out of chaos and establish a real public regulation over a business that had been so carelessly operated, we feel that the skies are clearing and that we shall have in Iowa within the next twelve months real and substantial control.

Cancellation of Certificates of Operation.—We have had difficulty when attempting to cancel certificates for non-observance of law or rules, because of the court's interference restraining the commission from enforcing its orders, and while we are not finding fault with this effort to protect the operator, it has affected seriously the respect for authority which any regulating body must have in order to function properly. However, a number of unsatisfactory operators—unsatisfactory because of their failure to pay taxes, failure to observe laws requiring stopping at railroad crossings, paying of insurance, keeping up the physical condition of vehicles—have ceased operating, their so-called franchises having been transferred to other and more responsible parties with the board's approval. We believe now that we may with some assurance of success require the keeping of accounts in standardized form so that we may know just what the financial results are from the operation of the various lines. It has been a serious doubt in our minds whether many of the lines operating were operating at a profit. Eventually, operation at a loss would mean cessation of service, and we believe it part of our duty to, if possible, preserve the service for the public. There have been too many cases where young men with a little money saved up have purchased with a first payment, a truck or a bus, only to find that their income was insufficient to provide for replacement, depreciation and pay current expenses of operation. We hope by our standard of accounts not only to preserve service to the public but to protect operators in the management of their own business.

Bus and Truck Service by Railways.—Some of you may recall that at Atlantic City a few years ago I strongly insisted that our rail lines, both steam and electric, should establish auxiliary service by both bus and truck, that the public was demanding this service and if the transportation lines already organized did not provide such service, others would; and that the public, no matter what we might think of its judgment, would get what it wanted, regardless of protest or artificial barriers erected by legislation or excessive taxation. I fear my advice fell upon deaf ears for in our own state, at least, the electric inter-urban lines have only recently been supplementing their rail service by the use of motor busses.

Our electric inter-urbans are now conducting splendid bus lines which have given us no trouble whatever in so far as obedience to laws, payment of taxes, and reliability of service. While I have no figures to quote, it is reported to me generally that this auxiliary bus service is making a satisfactory showing financially and is pleasing the public.

My own position is that wherever a rail transportation company desires to augment its service by the use of busses or trucks, or to extend its service for the public by new routes for busses or trucks, they should be permitted to so operate upon showing of course as provided by the statute, regardless of whether there is other bus or truck competition. I take this position because I believe that the public is more certain of service and is entitled to the best service obtainable. In Iowa none of our steam lines has added an auxiliary bus or truck service, although many lines in the East particularly are beginning to provide such service.

Long Haul by Busses.—While we may have thought that the bus was reserved for the short haul, I was amazed recently to find in Kansas City a busload of passengers coming in from Denver, having been about 24 hours on the way, and that there is a regular service between Kansas City and Los Angeles. I do not know just what this may mean but I do not believe such travel will ever take the place of through transportation on our great transcontinental railroads unless perhaps there should be a revival of the old stage coach days when people travelled more leisurely and became more acquainted with the country they traversed. It is possible there will be a reaction against the swiftness of modern travel and a desire to see our great continent in a more leisurely fashion. However this all may be, we are certainly passing through a transition period in transportation, the outcome of which I would not hazard a guess. I do not believe there is any prospect in sight that our great railroad companies are to be seriously impaired, either in service or in revenue by the advent of bus or truck lines, although undoubtedly tremendous changes are taking place in the handling of short hauls, both passengers and freight.

Requirements of Iowa Law.—The present Iowa law provides that it shall be unlawful for any motor carrier to operate or furnish public service without first obtaining from our Commission a certificate declaring that public convenience and necessity require such operation. A public hearing must be held, previous notice of which is given by publication. The cost to the Commission of such hearing must be paid for by the applicant. Anyone may make objections to the granting of the certificate and upon a decision anyone, party to the proceedings, may appeal to the court. No certificate of operation may be transferred without the Board's approval. Before a certificate is issued at all, the applicant must file

with the Commission a liability insurance bond in a form approved by the Commission and issued by some company authorized to do business in Iowa. This bond shall be in such sum as the Board shall determine will reasonably protect the travelling or shipping public. We have fixed the bond so that for instance a passenger vehicle with a capacity of from 21 to 25 persons must carry a bond of $25,000; other size vehicles in proportion. No motor carrier shall be permitted to operate upon the highways with solid tires which together with its maximum load weighs more than 7 tons. If equipped with pneumatic tires the gross weight shall not exceed 9 tons. Cities and towns regulate the operaion of motor vehicles within the corporate limits except that the board of railroad commissioners exercises jurisdiction over all of the mileage as to taxes, service, etc. The law requires that every motor vehicle and all its parts shall be maintained in a safe and sanitary condition, always subject to inspection by the Commission or its representatives. Every driver employed shall be at least 21 years of age, in good physical condition, good moral character, fully competent to operate, and in addition shall hold a regular chauffeur's license from the State Motor Vehicle Department. Passengers shall not be allowed to ride on the running boards, fenders, or any other outside part of the vehicle. All motor carrier vehicles shall stop at railroad crossings, and the speed is limited upon the highways to 30 miles per hour for passenger vehicles and 20 miles for freight. Accidents shall be reported promptly to the Commission, and each motor carrier vehicle shall have such distinctive marks or tags as shall be prescribed by the Board. For violation of any provisions of the act, the Commission may revoke and cancel the certificate and in addition to this, or aside from this the owner, officers, agents, or employees of any such motor carrier who violates or fails to comply with any provision of this act, or the rules and demands of the Board, shall be guilty of a misdemeanor and upon conviction shall be punished by a fine not exceeding $1,000 or be imprisoned in the county jail not exceeding 1 year, or by both such fine and imprisonment. In addition to these requirements of the statute, the board may make other rules and regulations, which it has done, and but recently issued its revised rules of 1926, the effective date being made as of March 1st. The statute also provides that the Board is vested with power and authority to require periodic inspection of any equipment, to fix or approve rates, fares, charges, regulate and supervise accounts, schedules, service and safety of operations, to provide a uniform system of classification of accounts which must include a proper setting up of depreciation charges, to require annual and other reports, and in so far as possible have such control over motor carriers as the Board now has by law over the operation of railroads and railroad companies. The law also provides that all rates shall be just, reasonable and non-discriminating. All other rates are declared unlawful.

Rules of Railroad Board.—The rules which the board has promulgated include the requirements made by statute and in addition provide how tariffs shall be printed, where posted; how schedules of operation shall be arranged for and their posting; and that no changes shall be made in schedules of operation or rates except by giving 30 days notice. Rates and schedules may be put into effect on less notice with the approval of the board. The rules provide that if two tires of the vehicle are solid, taxes shall be computed upon the basis of solid tires. The board's rules also provide that extra parts, tools, inside lights, windshield wipers, non-skid tire chains and extra tires shall be provided. A new rule has just been adopted which provides that no motor carrier operating any motor vehicle used in transportation of passengers or property, shall cause or allow any driver or operator of such vehicle to work as a driver or operator for more than a maximum of 12 driving hours in any twenty-four hour period and such driver or operator shall have at least 8 consecutive hours' rest in each twenty-four hour period. Every motor carrier vehicle must be provided with red flags and lights. No motor carrier operator shall knowingly carry in vehicle transporting passengers any high exposives, acids or inflammable liquid or article which will endanger life or limb. Gasoline tanks must be on the outside of the passenger compartment and must not be filled while the engine is running. Oil stoves shall not be burned in any passenger carrying vehicle while such vehicle is in motion. There shall be provided in each motor bus a fire extinguisher approved by the Underwriters Laboratories, Inc. Our rules also provide for available exit doors and speedometers, and that passengers shall not be permitted to board or alight from vehicles except on the right hand side nor until the vehicle has come to a full stop. The motor carrier tax law provides that if the tax is not paid promptly a penalty of 25 per cent. of the tax is added for such delinquency. If payment of taxes is not made on or before 60 days from the date when the tax is payable, the property of the carrier, or so much thereof as may be necessary, may be sold to satisfy the said taxes and penalty, interest and cost of sale. In connection with this provision of law, the

board's rules also provide that upon such 60 day delinquency "the board will consider that the motor carrier is not financially able to properly operate, and the certificate of Convenience and Necessity held by such motor carrier will be revoked."

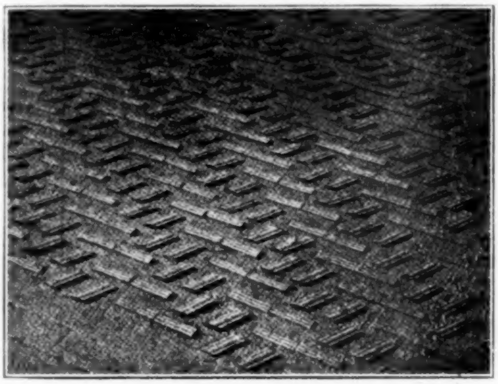
Administration of Motor Carrier Law.—Our commission has tried hard to administer the motor carrier law fairly and impartially with rather unsatisfactory results. Many bus and truck operators insist that we are partial to railroads and that it is hard for them to get a square deal because of our sympathy for the rail carriers, while at the same time the representatives of the railroad companies and railway trainmen, I fear, feel that we disregard their strenuous objections and thereby show favoritism toward bus and truck lines. It is not always easy to know to which side of a controversy to give the weight of judgment when both the applicants and the objectors have about an equal number of prominent citizens of their various committees for and against the proposed service, some claiming a public need and others declaring there is no such need. We have taken the position generally that where objection is made to a proposed line there must be an unusually strong showing as to public necessity and convenience to warrant the granting of a certificate. If it is shown there is ample and convenient rail service, such testimony is hard to be overcome, and we have turned down many applications for certificates of operation because of adequate present service While the service of the motor carrier on the public highways is comparatively new, it is going to be difficult to determine just its real place in the economy of transportation. It will be found, however, and this method of public transportation will eventually fit into its proper place with the least jar to established institutions.

An application recently heard by me excited the opposition of three railroad companies. It was shown, however, in testimony that in order to reach the three towns which this motor carrier of freight proposed to serve from a large distributing center, it took from three to five days to carry goods by train, while to the same towns over good highways the time consumed by motor carrier would be from three to five hours. The service proposed paralleled no railroad but did open up these three communities to this distributing center, which otherwise could not compete for business in these towns. It has been my thought that with the coming of hard surfaced roads the bus and truck business as public carriers may be profitably handled and in large measure should be auxiliary and feeder service for our railway systems. I do not know, of course, whether this will involve the eventual abandonment of the short branch lines or feeder lines but such a situation would not surprise me at all.

Personally I do not see why anyone would want to take a long continuous non-stop trip by bus but evidently there are many who do; and this may mean a serious inroad on the tourist travel on our railways. That situation is just developing. It may prove to be so unprofitable that it will not get very far. The National Association of Railway Commissioners is urging the passage of a bill by Congress providing for the regulation and control of motor busses and trucks acting as common carriers of interstate business. There is no legislation affecting that feature of bus and truck operation, and we are hopeful that Congress will pass the bill.

Wood Blocks With Rubber Insets

A section of pavement of wood blocks having rubber insets has been laid on the Uxbridge Road, at Acton, Middlesex, England. The system was devised by L. Wilton Cox, of Westminster, England, and is claimed to make for silence of traffic operation and also to prevent skidding. The accompanying illustration from an English contemporary, The Surveyor, shows the system.



Arrangement of Rubber Insets

The rubber is inserted in a groove cut in each wood block, and is held in position by a wedge-shaped piece of wood beneath the surface. The rubber projects about half an inch above the surface of the wood blocks. The curious herring-bone pattern of the rubber strips is designed to work a car up the camber of the road. The long and short strips are arranged at such an angle to each other that when a skid commences they keep the car straight, and do not let the back swing into the pavement. For roads, where the rule of the road is to drive on the right, they have to be cut at a different angle.

Standardization of Grade Separation Design

A Paper Presented at Annual Conference on Highway Engineering at University of Michigan

By C. F. MELICK
Bridge Engineer, State Highway Department of Michigan

The grade separation program in Michigan is rapidly becoming one of our major highway activities. We have but just begun the work of increasing the safety of our highways by protection, separation, or elimination of the railroad intersections with our highways. We are all familiar with the absolute inadequacy and feebleness of the little "dollar"-sized unilluminated standard railroad crossing sign in preventing us from crossing the deadly rails before we realize there is anything deadly in the neighborhood.

The monotony of the road, the prevalence of a large number of assorted and not always pertinent signs and obstructions to vision together with the universal habit of sitting in the front seat of our motor vehicles and distracting the driver's attention by a constant run of chatter, "talking with the motorman" so to speak, makes life particularly hazardous. At night, when you must in addition perforce, strike your own match and hunt for the dollar mark, the operator of a motor vehicle has but a fraction of the protection afforded in daylight.

Flashing Signal Protection at Crossings.—The flashing signals from powerful lenses operating day and night for any rail traffic within 1,500 ft. of the crossing is not too much for the public to demand at every crossing of railroad with highway. The common requirement of such minimum protection and the standardization of such equipment which is just as essential as the standardization of the traffic laws would soon put this equipment on a "Ford" basis, within the limits of the public purse. And, regardless of the cost, how much longer will we continue to set the price of even a single human life at so ridiculously small a figure. A phenomenal public sentiment demanding this protection is predicted for the near future as the last consideration for longer tolerating any grade crossing.

The absolute neglect and disgraceful lack of observance and enforcement of Michigan's so-called "Smooth and Even" grade crossing law is, with the growth in motor vehicle traffic and our stringent elimination of depressions greater than ¼ in. in our pavement construction, creating a further danger and public nuisance with which the public is becoming very impatient and radical measures are predicted for an early remedy. One of the greatest causes of traffic accidents today arises from some local condition, which if traveled over at fairly low speed would only jolt and shake us up a bit which, when encountered in the course of a concrete pavement which is traveled commonly at 45 miles per hour, would throw the car up in the air and either off of the highway or out of control, at least with inexperienced drivers who constitute probably 25 per cent of all drivers.

"Jay Walking" Highways.—The foolish "jay walking" of some of our highways, crossing and recrossing the railroads so frequently as to suggest that the highway locator was afraid of losing his way unless he tied in to the tracks frequently must be most searchingly and completely eliminated. Legislation protecting the public from the sins of the past would not be an unreasonable remedy for this evil. The selfish interests of local communities which have sprung up on such improperly located highways must be ignored and publicity directed to offset the natural phase of such communities not to be cut off of the highway. Elimination of such death centers is being given considerable attention by the state highway department and such elimination measures are cures and not merely prescriptions and are usually effected at but little cost.

Under the present laws of this state the railroads do not pay one cent towards this best of all methods of handling the crossing problem, although they are required to pay one-half the cost when elimination by grade separation is resorted to. What a wonderful stimulus to interchange of rights of way, to mutual concessions and the cheapest and best treatment of this problem would be given by a requirement that the railroads bear one-half of such costs and that the items making up these costs be most carefully defined so as to form a businesslike working rule for negotiations.

Grade Separation the Real Remedy.—The grade separation is the "solution de luxe" and

in the majority of cases perhaps the only real remedy since there is always a limit to the additional distance one will travel to avoid a danger and especially so for the American public which is constantly in search of thrills.

A grade separation at its best is not a very desirable piece of our highway system. It always implies a waste rise and fall hazard. The tendency is to use the maximum gradients and the shortest vertical curves in order to reduce the huge expense to a lesser figure. It always places a limiting restriction on the sight distance for approaching vehicles. It climaxes the traffic at points where the possibilities for congestion are the greatest and the most hazardous. It always creates a topographic situation which is adverse to the best interests of property frontage.

For overhead jobs the public must ride a relatively narrow hogback and for underpasses the drainage conditions are seldom satisfactory. The costs are so great that conditions and facilities provided on the normal section of the highway must be greatly reduced at the grade separations which thus constitute the most hazardous points. The widening provisions for future growth of traffic are by no means so simple or inexpensive as obtains for the widening of the normal road cross section. And yet with all its faults, it is a 100 per cent cure for the deadly railroad crossing accidents and fatalities, even at the expense of taking on a tendency toward other hazards which are insignificant in consequence as compared to collision with a railroad locomotive.

Standardization a Matter of Co-operation.— Standardization in the design of grade separations is a most difficult but not an impossible thing, at least as applying to certain features of the design. The greatest hindrance to standardization is the fact that each railroad has its own clearance requirements and design practices, and that the highway departments have widely varying sets of requirements and these various idiosyncrasies must each be considered for each individual job. This makes standardization a matter of co-operation. A common ground for design acceptable to all railroads in the state is a necessity precedent to standardization.

The fact that railroads were not laid out on the "rectangular" system, as applies to our highway system, makes practically every railroad crossing a skew crossing and details always will be different for each separation job.

In general it is believed that grade separations carrying the highway over the railroad should be of the three-span skeleton type with the central span designed to provide for two tracks whether the second track exists at the time or not. If no second track is anticipated in the future, the cost of the extra span length used is saved by letting the fill spill past the piers, thus either decreasing the end span or the materials in the wings.

The abutment should be of the stub type with as little material in the wings as possible since the fill retained is not subject to scour and immersion in water as occurs for bridge structures. The end span should, however, be made a minimum to provide for one track or siding at standard clearances thus requiring, in case of such increased railroad facilities, only the addition of wings and retaining wall without interrupting traffic or wasting any part of the structure.

The railroads could well agree on standard side and vertical clearances both for permanent and for construction clearances. Permanent clearance heights above top of rail of 18 ft. for interurban roads and of 22 ft. for steam lines should probably be standard and permanent clearance widths of 8 ft. 6 in. for either traffic from center line of track to face of masonry between top of rail and bridge seat seem adequate. For construction purposes, these heights should be cut to 14 ft. and 18 ft. respectively and widths to 7 ft. except that sheeting for footings might be driven within 5 ft. 6 in. of center line of track subject to railroad supervision.

All side ditches should be diverted into pipe located in front of the pier adjacent to the track and concrete headwalls provided at inlet and outlet of the ditch and pipe sections and grading carried over same at subgrade elevation and then ballasted to within 2 or 3 in. of face of rail elevation clear up to the pier. All piers should be protected at each end by heavy concrete bull nozed pedestals in front of the pier nose to serve as collision deflections since a collision with a slender pier shaft would be disastrous to the entire structure.

Piers and superstructures should invariably be of reinforced concrete since this effects a considerable saving in cost unless the angle of crossing is less than about 45 degrees or more than two tracks are included in a single span, both of which conditions should by all means be avoided by relocation if at all possible not only because of the saving in cost to be effected but also because of the lack of rigidity in such structures.

The value of a straight line in highway and railway construction is often over-emphasized when these problems are considered. The costs and difficulties and unsatisfactory conditions attending grade separation construction increase very rapidly when angles of less than 45 degrees are encountered.

Width of Bridge, Roadways and Walks.— The most lively differences of opinion exist today as to what constitutes an adequate width of roadway and provision for sidewalks on our bridges. This condition is even more nebulous

when applied to the requirements of the future. It is certain the requirement for a bridge of sufficient width to permit laying a 20-ft. pavement across it would eliminate practically every bridge put under contract by the state up to about July 1, 1920, so rapidly have our traffic conditions and our conceptions of the future requirements grown. Our standard roadway widths are now 22, 30, and 40 ft. between curbs.

Piers should consist of large rectangular spread footings each supporting a rectangular shaft and each shaft carrying a spread or cantilevered capital and taking its load from a transverse girder, these girders supporting the longitudinal girders or T-beams of the superstructure proper. Base and shaft can be standardized by using one such unit per traffic lane. The transverse girder, which merely equalizes the loads to the deep cantilevered capitals of the shafts can also be standardized for square jobs, but for skew jobs will need special reinforcing if economy is to be observed. Abutments can be similarly standardized for square crossings but for skew jobs must be given special design consideration.

Superstructures should be so designed that widening may in the future be provided by adding a new traffic lane on either or both sides, although widening on one side only requires the concession of shifting the center line of paving five feet to one side of the existing center line. Symmetry would then indicate either a 22 ft. or a 40 ft. roadway with no intermediate widths.

Transverse girders and shaft cantilevers should be designed for the contingency of supporting sidewalks girders directly on the transverse girders as there seems to be no way of safely predicting when sidewalk should be provided for.

The idea that sidewalks can be cheaply cantilevered from the outside beam is usually erroneous. The cheapest way to carry the walks is by placing an additional longitudinal beam on the outside under the railing. The widths of walk heretofore provided has always in the past been 5 ft., but it must be admitted that, however adequate this may be for the traffic, it looks stunted and stingy when used on a bridge with a 40-ft. roadway and it is thought that a 6-ft. walk is the least which would be appropriate for such conditions.

Approaches.—The grades up to the structure should be based on a long sight distance and traction consideration given for the heaviest traffic likely ever to use the roads on which the structure is placed and a 4 per cent grade with 200-ft. vertical curve at the top will provide a sight distance of 600 ft. which is considerably greater than the sight distance (530 ft.) corresponding to a 3 per cent grade rise and fall over a pavement summit with a 400 ft. vertical curve. Longer vertical curves would be inconsistent and flatter grades are not warranted in comparison with the grades commonly encountered on our heavy duty paved roads.

Approaches should never be placed on a curve and deep curb and gutter sections should be provided both for safety and for drainage the full length of the approach grades. Shoulders should be wide enough to permit parking or 10 ft. outside of the road metal proper and should be sodded or surfaced and adequate guard rail furnished. The roadway width inside of curbs should be uniform from end to end of approaches.

Superstructure should be of the deck type to permit widening and standardization. Recent tests on bond of concrete to structural rolled shapes indicate that for skews of less than 45° the use of Bethlehem girder sections encased to the bottom flanges and designed as T-beams including the slab as a part of the beam may become the most economical type of superstructure, dispensing with flasework, but for the present the reinforced T-beam type proves the more economical.

Subway Types of Grade Separations.—For subway types of grade separations, it is unwise to provide less than the ultimate possible roadway requirements of 40 ft. inside of curbs in a single clear span. Divided roadways but add a serious menace to the safety of traffic and should not be tolerated in a structure whose sole purpose is to increase the public safety and convenience; a 100 per cent job should be made of it. Similarly, every subway should provide sidewalks since the job is a permanent one and additional facilities under railroad traffic can only be provided at an expense altogether out of proportion to the value of the improvement and the resulting job is necessarily a patchwork job and unsightly and not in conformity to a proper development of street properties.

All sidewalks in depressed highways such as subways should be located back from the curb to avoid danger to pedestrians from overhanging loads and to protect pedestrians from slush and water splashed from the roadway.

Curb columns provide an admirable means of separating walk from curb, reducing the superstructure spans and providing a support for a concrete splash guard in addition to the curb protection at that part of the structure where slush and water troubles will be most likely to occur. Curbs in these subways should not be less than 10 in. deep and should provide not less than 9 in. clear from the column faces.

A minimum overhead clearance of 14 ft. should be standardized. There is an indication that 15-ft. clearance is growing in popularity but with 12 ft. specified as the maximum legal

height of a vehicle, the maximum heights using the streets of Chicago reported as 12 ft. 6 in. and the additional 4 in. provided in the pavement crown, it is felt that 15 ft. is a little too optimistic a provision for the unknown.

The width of sidewalks is a much discussed question. There is but little doubt that a 5-ft. walk on each side would take all the traffic at any of our grade separations without congestion. When curb columns are used the walks should be lighted and a wide walk in such cases adds to the convenience and safety of the public. It is believed that a walk of 6-ft. width should be standard. This will provide 3 ft. from curb to walk for park space, a 6-ft. walk, and 3 ft. from walk to foot of slope for park space and blind drain or 12 ft. width for walk and park spaces or a prism section in excavation of 64 ft. width at approximate top of curb level. If the walkway is not needed at once the prism section might be made 46 ft. wide, allowing an 18-in. safety walk along the curb to permit pedestrians to evade the traffic and 18 in. for sod and blind drains.

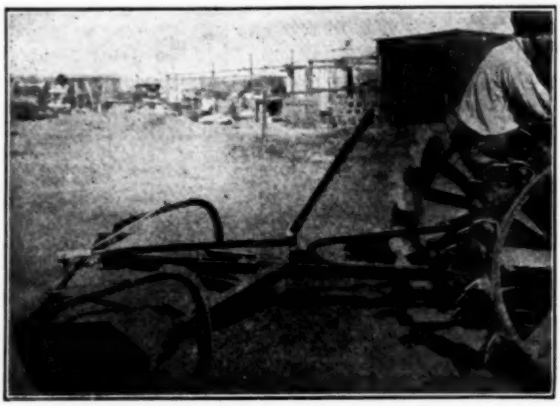
If railroads could all agree a reinforced concrete abutment which provides a single footing for curb columns and abutment wall and concentrate all superstructure loading centrally over this footing can be used with great economy, the abutment wall being only 24 in. thick and the curb columns made monolithic with and portal braced to the abutment wall. Such a structure is now being rapidly completed at Grape, in Monroe country on Trunk Line No. 65 under the D. & I. railroad.

The use of a combined footing practiced to some extent with superstructure bearings at curb column and abutment walls is undesirable because of the extreme and rapid shift of footing pressures as heavy concentrations pas successively over the two bearing points. This condition is obviated by the Grape design. It is not believed that it pays to encase the bottom surfaces of the bottom flanges of the steel girders of the superstructure or the outside faces of the girders, but that encasing should be cast to thoroughly encase the insides of girders and the stringers and floor beams leaving only outside and bottom surfaces to paint. Corrosion of these parts is very slow. If the railroad companies would spread track to 14 ft. centers for this type of structure the girder faces of adjacent girders for double track work would be easily accessible from below for field painting avoiding the mutilation and weakening of flanges and omission of web stiffeners now so common where 13-ft. centers are maintained.

The painting and cleaning of large flat surfaces is comparatively a very cheap job and encasement under the circumstances is not warranted. The superstructure of half through type with top flange of girder at elevation of base of rail and encasement extending over top flange to outside face of cover plates is deservedly popular, gives a shallow flow, a solid ballasted concrete deck and permits standard track spacing and absolute safety from dragging brake gear or derailments. A safety walk of about three-foot width in addition to the seven-foot clearance from center line of track is considered essential for the safety of train men and passengers. The underpass which has to be drained artificially by automatic pumping is rapidly becoming a workable and satisfactory type. Provision for heating inlet drain castings to make position drainage into the pump pit during icy conditions of the pavement will greatly aid in making this type satisfactory. Considerable progress is anticipated during the coming season in the process of standardization of design for grade separations.

Tractor Scraper

The Slusser-McLean Scraper Co. of Selbey, Ohio, manufacturers of earth working equipment, has arranged to manufacture the "Atlas"



"Atlas" 1-Man Fresno Hitch and Scraper

one-man Fresno hitch and scraper. The "Atlas" can be attached to any standard Fresno scraper without drilling holes. This combination is stated to make one of the most practical dirt movers for the tractor. Features claimed for the outfit include: Rigid levers for loading and dumping, within the reach of driver at all times; pulling arms curved to give clearance for dirt in loading; spreading the load three different thicknesses while the tractor moves forward; a rigid connecting link from top of scraper to control lever insures full load to dump; breaks bite, if necessary.

Concrete in Tension

Tests to Compare Ratio of Strengths in Tension and Compression Described in Paper Presented June 22 at 29th Annual Meeting of American Society for Testing Materials

By A. N. JOHNSON

Dean, College of Engineering, University of Maryland

The tests here described are the result of cooperative work between the University of Maryland, the State Roads Commission of Maryland and the U. S. Bureau of Public Roads.

The purpose was to secure more data as to the relative strength of mortar and concrete specimens in compression and tension, the tension specimens to have a cross-sectional area equal to that of the compression specimens. To do this required special apparatus which was designed and made in the shops of the University of Maryland.

Test Specimens.—Each tension specimen consists essentially of a cylindrical section 9 in. long by 4½ in. in diameter, on each end of which inverted frustums of cones were made, so that the total length of the specimen was nearly 21 in. The cylindrical portion of the specimen was the size of the cylinders used in the compression tests, 9 in. long by 4½ in. in diameter. The tension test specimens were cast in brass molds which were split their entire length and bolted together. Before casting a specimen, the molds were rubbed with an oily rag. The concrete was put in from one end and tamped with a rod. While the concrete was being placed, the molds were hit with a wooden mallet which resulted in a concrete free from small air pockets.

The compression specimens were cast in steel molds which were made by splitting seamless tubing along one element of the cylinder and holding the edges together by means of bolts attached to lugs. Compression specimens were tamped as the concrete was poured in one end and the molds were also struck with a wooden mallet.

From a given batch of mortar or concrete, three compression and three tension specimens were made. No particular care was taken, however, that the various batches should have the same water ratio. The sand was quartz containing 4 to 5 per cent of silt, wet measure, with a trace of inorganic impurities, and had a fineness modulus of 3.28. The coarse aggregate was limestone not exceeding 1 in. in size, having a fineness modulus of 6.20. The mortar specimens were made up of 1 part of cement to 2 parts of sand. The concrete specimens were made up of 1 part of cement, 2 parts of sand, and 3 parts of coarse aggregate.

The specimens were stored in damp sand for about two weeks and then removed to a

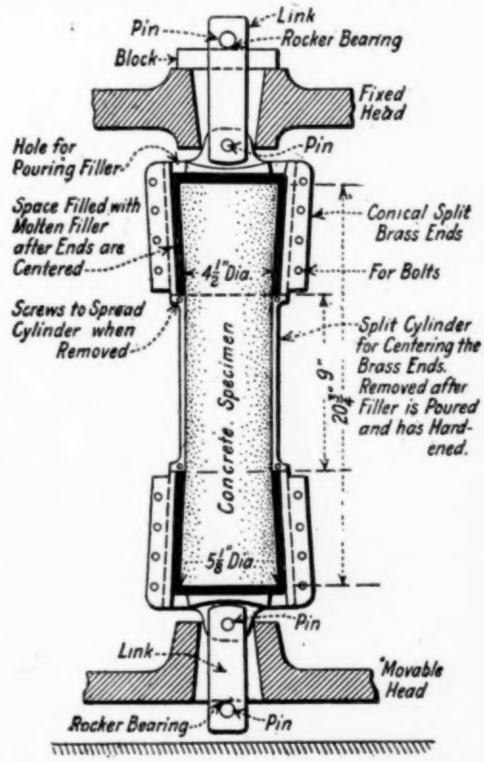


Fig. 1—Arrangement of Concrete Specimen for Tension Tests

room in the laboratory. They were tested at various ages up to eight or nine months.

Method of Testing.—In the design of the apparatus to hold the tension specimen, special care was taken to insure that the geometric axis of the tension specimen should coincide with the line of force applied to the specimens by the testing machine. This was accomplished as follows: in preparing the tension

specimens for test, the cylindrical portion was surrounded by a split aluminum cylinder, held in place by a wooden clamp. Brass ends were made so that the opening was sufficiently large to go over the head of the tension specimen. These brass ends were split and bolted together when ready for use. They rested upon the aluminum cylinder by means of which it was possible accurately to center them with reference to the axis of the specimen. There was thus left an annular space between the brass end piece and the specimen which was filled with melted rosin poured through holes at the top. As soon as both end pieces had been thus placed, the aluminum cylinder surrounding the center portion of the specimen was removed. Reference to Fig. 1 will show the arrangement of the specimen and tne apparatus. The diagram shows clearly how, by means of links and pins with rocker bearings, the specimen was mounted in the machine in such a manner that there was no twist or eccentric loading given the specimen during the application of the load. A 100,000-lb. Riehlé machine was used for these tests, the load being applied slowly by hand. In operation, the apparatus worked very satisfactorily.

Practically all the concrete tension specimens broke within or near the middle third of the cylindrical portion of the specimen, while a greater number of the mortar tension specimens broke near one clip or the other. In all instances, the breaks were nearly planes perpendicular to the axis of the specimen.

The compression tests were made with a spherical bearing block and usually a very thin cap of plaster was applied to the ends to insure flat bearings.

TABLE I.—RESULTS OF COMPRESSION AND TENSION TESTS OF CEMENT MORTAR (MIX 1:2).

Cross-sectional area 16 sq. in. (approximately). Each result, average of 3 specimens.

Age, days	Compressive Strength, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Ratio, Tensile to Compressive Strength	Age, days	Compressive Strength, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Ratio, Tensile to Compressive Strength
20	2510	349	0.14	162	6123	399	0.07
47	3827	421	0.11	167	6750	431	0.06
55	2640	442	0.17	173	7133	466	0.07
76	4990	434	0.09	184	5790	525	0.09
85	4200	370	0.09	191	6340	630	0.10
137	6230	347	0.06	198	5420	494	0.09
139	7140	489	Q.07	199	5873	496	0.08
141	7183	434	0.06	212	5613	541	0.10
151	7577	488	0.06	253	6063	547	0.08
156	7223	583	0.08	255	6183	505	0.08

TABLE II.—RESULTS OF COMPRESSION AND TENSION TESTS OF CEMENT CONCRETE (MIX 1:2:3).

Cross-sectional area 16 sq. in. (approximately). Each result, average of 3 specimens.

Age, days	Compressive Strength, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Ratio, Tensile to Compressive Strength	Age, days	Compressive Strength, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Ratio, Tensile to Compressive Strength
18	1297	...	....	181	1847	155	0.08
33	2160	349	0.16	185	4280	326	0.08
50	3197	335	0.10	192	3773	301	0.08
69	3043	360	0.12	194	4667	307	0.07
83	3007	220	0.07	196	2130	192	0.09
90	2503	126	0.05	197	2863	235	0.08
140	3353	334	0.10	200	2503	236	0.09
146	4160	369	0.09	215	4260	330	0.08
154	4175	293	0.07	225	3337	298	0.09
159	3310	244	0.07	239	3647	284	0.08
165	3473	257	0.07	243	2797	247	0.09
172	3023	221	0.07	249	3373	248	0.07

Test Results.—The results obtained are detailed in Tables I and II. Table I shows the results for the mortar specimens, and Table II for the concrete specimens. It will be noted, first, that the ratio of tensile to compressive strength is practically the same for the mortar specimens as for the concrete specimens; and, second, that for specimens up to 90 days old the ratio in each case varies from 0.15 to 0.08, and after this period, the ratio becomes practically constant at 0.08. Thus, there is not the proportionate increase in tensile strength due to the age of the concrete as is the case

with compression during the first 60 to 90 days, but beyond this time it appears that both are modified in practically the same ratio. Then relations are brought out clearly in Fig. 2.

The agreement of the results seems so persistent, even for considerably wide variation in the character of the concrete, that there exists considerable definite evidence as to the ratio between the tensile strength and compressive strength. Thus, in any given case the compressive strength being determined, the tensile strength is known with sufficient accuracy for most purposes.

The lack of any attempt to control the water ratio and the comparatively short period of curing accounts for the irregularity in the results when compared with the age of the specimens. As it was the intent primarily to study the ratio of tensile to compressive strengths, it was not necessary, in fact probably better, that there be a varity in the specimens that would correspond with variations that might be expected in most commercial work.

Modulus of Elasticity of Concrete in Tension.—During these experiments, a few measurements were made to determine the elastic curve of the concrete in tension. It is, perhaps, sufficient here to state a few of the results obtained. The method of observing the deformations in tension was by means of a mirror extensometer attached in a manner similar for observations of compression cylinders which was fully described in a previous paper by the author.* As illustrative of some of the results obtained, attention is called to Fig. 3, which shows the deformations obtained upon a 1:2 mortar specimen, which broke at 340 lb. per sq. in., and indicates a modulus of elasticity of 4,200,000 lb. per sq. in. The values of E for the few specimens tested varied from 3,300,000 to over 5,000,000 lb. per sq. in. for some specimens.

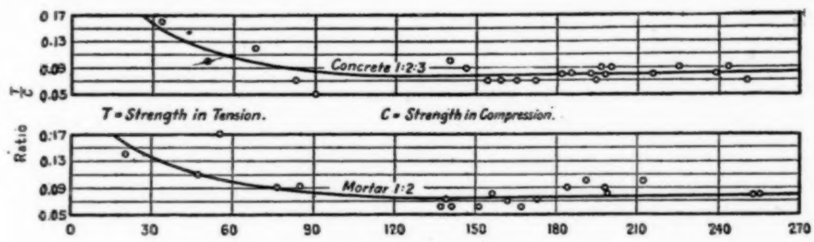


Fig. 2—Relation Between Ratio of Tensile Strength to Compressive Strength and Age of Concrete

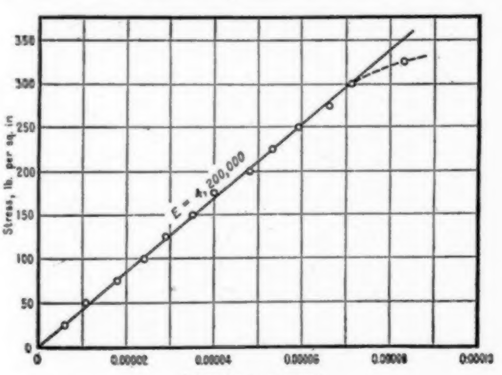


Fig. 3—Stress-Strain Diagram of Cement Motor (1:2) Cylinder in Tension
Age 67 Days and Broke at 340 lb. per Square Inch, at Center

It is the expectation to carry on a more extended series of observations of the modulus elasticity of concrete in tension, particularly with alumina cement.

Economical Gravel Spreading Arrangement

By merely cutting a hole in the end of the tail gate of a truck and extending a plate out from the floor, P. L. Boneysteele, maintenance engineer, Nevada Highway Department, has devised an ingenious method for the economical replacement of gravel next to the edge of the pavement when the earth shoulder has been worn away or grooved.

According to The Highway Magazine this device has proved particularly valuable in Nevada, as a large amount of re-shouldering was on the program. The truck used had a dump body which could be tilted at just the right angle, thus insuring a uniform rate of spread in spite of variations in truck speed and height of the material in the truck.

The driver was able to spread the gravel by himself, and only a small amount of shovel work was needed to dress up the shoulders. This truck also has been employed advantageously in placing small stock piles alongside the road for patching and repairs.

*A. N. Johnson, "Direct Measurement of Poisson's Ratio for Concrete," Proceedings, Am. Soc. Testing Mats., Vol. 24, Part II, p. 1024 (1924).

Modern Crushed Stone and Gravel Surfacing

A Paper Presented at the Summer Meeting of the American Society of Civil Engineers, Seattle, Wash., July, 1926

By J. W. HOOVER
State Highway Engineer of Washington

Much might be said of the economic value of the type of surfacing to be considered here, of the volume of traffic that will justify the change from a dirt road to a gravel or crushed rock surface and from such surfaces to the more expensive and satisfactory pavement. However, it is assumed that these changes are sound and well recognized in principle. The actual period in the growth of traffic at which each change becomes economically advisable must be determined for each road on its merits. To state that a traffic of 300 cars or 400 cars per day or so many tons per day justify a change of type of surfacing as a general proposition is to err. The cost of each item involved in the maintenance of the existing surface and the cost of each item involved in the construction and maintenance of a higher type of surface vary in each locality. The value worked out for a highway in this state would not serve in another state except as a coincidence; the principal involved is the same, however, and should be based on the various costs as affected by subgrade, traffic and climate.

The most important consideration is certainly overlooked when weighing the dollars involved; that is, service to the public. Just how good a road is the public entitled to have? As a general rule the automobile owner is supplying the funds; it is his money and his road; how good should it be?

When to Change Type of Surface.—A number of the papers published in current magazines fix the time for paving a highway at from 400 to 500 cars per day or approximately the same number of tons per day based on certain average conditions in certain localities. None have been found attempting to fix the volume of traffic considered sufficient to justify gravel surfacing; the general idea seems to be that if a road is worth building at all, a gravel surface is also justified. As a general rule I doubt if many paved roads are carrying less than 1,000 cars per day and certainly thousands of miles of gravel roads are carrying more than 1,500 cars per day.

After all, at the present time the question as to the time to change the type of surface is dependent upon the funds available and seldom upon the real economics of the situation for the reason that we are far behind the requirements of traffic. A very large percentage of the highways of the nation are now carrying more traffic than the width and type of surface justify considering the economic value and the service to which the public feels entitled. The question now is which road shall be improved first and it may be answered on the basis of a traffic study although often the decision is made by the legislative body making the appropriations for highway work, disregarding the merits of the respective roads.

The Subgrade.—The subgrade on which the surfacing materials are to be placed should be given such preparation as is necessary to provide a well drained stable foundation. Consideration should be given the soil, practical drainage where necessary and the climate before the selection of the materials to form the surface metal is made and before the width and thickness of surface is determined.

After the value of the subgrade as a foundation has been studied and the present and probable future traffic that the surface will carry is analyzed the metal either gravel, crushed gravel or crushed rock may be selected. Such selection is a matter of economics with the criterion that the material selected shall give the service required at the least cost. Going hand in hand with the selection of the metal is the matter of the design of the cross-section.

Design of Cross-Section.—A surface 12 ft. wide and 6 in. thick is often all that is necessary for light traffic. However, there is and will no doubt be for sometime a very large mileage of unpaved highway that is subjected to traffic in an amount sufficient to justify paving. In selecting a design or surfacing for this traffic as well as for a volume of traffic for which metal surfacing is suited a cross-section following more closely to pavement design is recommended. The metal should be placed for a width of not less than 18 ft. and should have a thickness at the edges of from 9 to 10 in. and a thickness across the center

of from 7 to 8 in. Where the subgrade is unstable additional thickness of metal should be provided. A design similar to the above is of more importance where the more expensive water bound macadams and dust prevention methods through oiling or other surface treatments are contemplated or probable in the near future.

Size of Surfacing Material.—The maximum size of gravel or crushed rock was first rather large, often running as high as 3 in. As maintenance methods became more extensive the size was cut down until the extreme of 1½ in. for the base course and ¾ in. for the top course became common with occasional specifications limiting the base rock to a maximum of 1 in. and the top course to ¾ in.

Practically all of these roads were maintained by frequent dragging and the ideal was expressed as a smooth compact base covered with from ½ in. to 1 in. of loose material to be worked back and forth across the road by means of the drag or grader. Highway surface construction passed through the coarse rock stage and there is now a large mileage of fine rock surfacing that may be treated to give a surface free from dust.

There is now developing a tendency to change to coarser rock or gravel in surface treatments to secure a smooth compact surface free from loose material particularly where the travel is heavy and where dust prevention is desirable.

Selection of Surfacing Material.—Selection of gravel, crushed gravel or crushed rock as a surfacing material has been based largely on the cost of the material on the road. This has resulted in natural gravel surfaces or crushed gravel surfaces in the glaciated areas and crushed rock surfaces in unglaciated areas. Crushed rock has in general given the best service with crushed gravel and pit run screened gravel in the order named. There are exceptions as some deposits of natural occurring fine gravel can be worked into roadways comparable in every way with the best crushed rock.

The question of hardness of gravel or rock for surfacing has been given a great deal of study and in general the limits set forth in the specifications of the various states no doubt produce good results. It is not practical to use the same specifications in all of the states for the reason that the specifications must be fitted to the materials available, the soil, traffic and climatic conditions. Very often material is found that would not pass the specified tests, nevertheless it makes the best of road surfacing under the circumstances. The policy of the State of Washington is to test the materials available before the contract is advertised. The bidders are then advised by the special specifications as to the requirements for each grade of material. In this way the contractor is fully advised before making his bid as to the sources of gravel or rock, the element of gamble is materially reduced and the state receives a better bid for the work.

Specifications.—Following is a short review of gravel or crushed rock surfacing specifications for a roadway that is to be maintained by dragging loose material back and forth.

The subgrade shall be smooth and true to the required cross section and all large rock removed.

The surfacing material shall be uniformly distributed on the subgrade. If the inspector should be lax in this requirement the surfacing when completed will not be smooth and traffic will work depressions at the point where the material is not uniform and it will be sometime after the work is completed before the maintenance forces can work up a first class riding surface. The usual specifications also require that the contractor insofar as it is practical shall do his hauling over the surfacing as it is placed. In order to accomplish this the surfacing is started at the point of loading or the point of entrance on to the highway and worked away from that point.

It is also necessary to drag the surfacing material as much as is necessary to keep it smooth. Where the surfacing is to be constructed in two courses, the contractor is required to construct as much of the base course as is possible from any one set up of bunkers before beginning the construction of the top course. Where the entire product of the crusher is to be placed in the base course, it is required that the entire base course shall be constructed before starting on the top course and where the product of the crusher is separated into two sizes only the base course shall be constructed until the section of the bunkers for the finer material is filled at which time the top course may be started. In this way the hauling equipment is used to secure as much compacting of the two courses as is practical. By dragging the surfacing and keeping it smooth the trucks do not run in the same tracks and the traffic is distributed over a wider area.

Binding Material.—Very few specifications give sufficient attention to the binding material required to be added to the surfacing. The usual specifications permit the use of side of the road material or any other material that is easily available and having some binding quantities. The binding material should be a water resistent clay, which when mixed with the surfacing material will harden.

The State of Oregon has given this part of the work a great deal of thought and attention during the past few years and has secured very good results.

Too much emphasis cannot be placed upon the necessity for keeping the subgrade smooth and each course of surfacing smooth during the entire operation of constructing the road and afterwards by means of the maintenance organization. The best results are obtained in this type of surfacing by constructing in at least two courses. The base course containing rock having maximum size of 1½ in. and the top course composed of rock which will pass a ¾ in. ring. The two courses should be of equal thickness which should be for each not less than 3 in. The thickness of the surfacing depends upon the character of the subgrade, the traffic and the climatic conditions. In some regions such as the arid regions of Washington where the rain fall is only from 6 to 10 in. per year, light surfacing holds up very well. In other localities a very heavy course of surfacing is necessary by reason of a rain fall that is more than 100 in. per year and a subgrade that becomes very soft when wet. The best results in the heavy rain fall area are obtained by using the product of the crusher in the base course as this builds up into a crust with comparatively little binder due to the interlocking effect of the crushed material. In the arid regions the product of the crusher may be separated into the two sizes and the base course bound up with good clay and the top course placed and bound up with clay. A great variety of specifications for the size of material in each course is possible, dependent upon the materials that are available to provide the facilities for traffic at the least cost.

The available materials should be given thorough study for each project. Of course in some localities there is no choice. Surfacing constructed in more than two courses is often times advisable due to a soft subgrade that cannot be cared for by drainage or by raising the grade line without excessive cost; in some instances a base course of large rock is advisable and economical.

Maintenance.—The maintenance of gravel or crushed rock surfaces is based on dragging with a grader or drag having a comparatively long wheel base. Some roads must be dragged more often than others depending on the stability of the subgrade, the character of the surface, the character and volume of traffic and the climatic conditions. Additional material must be added as the original material is ground up and blown away or pounded into the subgrade. The surface must be kept smooth at all times for if it once becomes rough a considerable cost is entailed in scarifying, reshaping and compacting the material into a smooth surface.

The methods of surface treatment with oils developed or in process of development by such states as Oregon, Wisconsin, Michigan, and a number of other states give promise of eliminating the dust nuisance. For some states this surface treatment will necessitate a considerable additional initial outlay as the type of surfacing constructed in the past is not adapted to oil treatment and is less expensive than that which the oil treatment seems to require. While I have not seen the oiled roads of states other than Oregon, I am much pleased with results secured east of the Cascade Mountains in that state and believe that anyone interested can profitably spend a few days studying their methods and results.

There is no final answer—no one final specifications for a modern crushed stone or gravel road; possibly there are but few fundamentals that will apply under all circumstances. The conditions of soil, climate, traffic, materials of construction and funds fix the limits to which construction may be carried. Surfacing of the type discussed in this paper is undergoing thorough research and will be developed to a higher type of construction just as research developed the type of modern pavements. The science of highway engineering has made wonderful strides in the past ten years along many lines and gives promise of splendid development for the production of a surface to serve adequately and well pending the construction of the higher types of pavement.

Many Earth-Lime Studies Under Way

A number of experiments on the use of lime on earth roads and for subgrade treatment will be under way this summer, according to Highway Research News.

Test roads are being built in Wisconsin, using a thin gravel surface over the lime-treated subgrade. This work will be done by the Maintenance Section of the Wisconsin State Highway Department.

The University of Illinois is building several test sections near Champaign to determine the value of lime treatment preparatory to oiling earth roads. It is expected that the lime will stabilize the soil, and at the same time prevent the emulsifying of the oil by the clay.

In Missouri and Virginia sections are being treated with lime to obtain further information concerning its use on earth roads without the addition of any surfacing material. In Ohio another short section of subgrade for concrete pavement has just been completed, and the test in the laboratories at Ohio State University are progressing.

State Highway Officials Meeting.—The annual meeting of the American Association of State Highway Officials will be held, this year, at Pinehurst, N. C., Nov. 8 to 12.

Survey of Soil and Pavement Conditions

How a Combined Survey Is Being Made in Michigan Described in June Public Roads

By V. R. BURTON

Engineer in Special Assignments, Michigan State Highway Department

A combined pavement condition and soil survey was begun by the Michigan State Highway Department late in the fall of 1925. The work was discontinued because of extremely wet weather and subsequent freezing. At the time the operations were temporarily halted 108 miles of pavement-condition surveys had been made and 16 miles of general soil surveys were finished. The plans for 1926 include the survey of the remaining 2,000 miles on the state highway system. Whether the work will be accomplished depends to some extent upon the funds available. However, it is the intention to cover during the coming season at least a large variety of soils and pavement designs. Sufficient work has been done already to determine upon adequate methods for collecting and classifying the information; and the 1926 work will be begun with a clear understanding of the organization and methods necessary to complete the survey. Acknowledgment should be made of the material assistance secured from a study of the methods of the Pennsylvania State Highway Department pavement-condition survey.

Pavement Designs. — The building of concrete pavements in Michigan has been going on at an increasing rate for the past 15 years, and it is probable that they will continue to be the predominating type of hard-surfaced road in the state. The designs of pavement slabs vary from the old 6-8-6 cross section with expansion joints at 30-ft. intervals, through the 7 and 8 in. uniform thickness with or without expansion joints, to the existing 1924 sections with 10-8-10, 9-7-9, and 9-6-9 dimensions varied to suit the demands of traffic and the character of the subgrade. Various methods of subgrade treatment of the porous subbase type have been used in a more or less experimental way since 1921. Different designs of subdrainage and steel reinforcement have been in use throughout the same period.

The service records of the different types of design throughout the state should furnish some valuable information. It only remains to collect and classify these data for the purpose of deciding upon the relative effectiveness of the various methods of construction, materials, and workmanship has been recorded by the state highway department especially on the more recent state-supervised jobs. The pavement survey was projected, therefore, to cover the major portion, if not all, of the pavements laid to date.

Lack of knowledge of the kinds and properties of subgrade soils is the most serious obstacle to a better understanding of the differences in the behavior of pavements laid under apparently identical conditions. It has been felt that this factor must be taken into consideration to make the pavement-condition survey of any great value. It seems to be generally believed that most sandy soils provide a good subgrade while clay soils as a rule are poor subgrade material. The intermediate type, however, with which we are more often concerned seems to be little understood or worse still, not even recognized.

The decision has been made, therefore, to carry on a soil survey concurrently with the pavement survey for the purpose of determining the proper subgrade and pavement design suitable for a particular soil type under given climatic and traffic conditions. A discussion of this phase of the matter with the official in charge of the land economic survey being carried on in Michigan brought out the fact that about one-third of the State had been covered by some sort of soil survey by that agency and the state agricultural college, both in co-operation with the Bureau of Soils of the United States Department of Agriculture. The older soil maps are, for our purpose, of limited value only since the science of soil mapping and testing has been undergoing almost as rapid a change as that of highway engineering. In addition, the condition and properties of a subgrade soil must be determined in greater detail and from a different viewpoint than even the most recent agricultural soil maps will permit.

Bureau of Soils Surveys Reduce Labor of Subgrade Study.—By adopting the Bureau of Soils classification of series and types and profiles it seems possible to diminish to a considerable extent the amount of laboratory testing. For instance the Fox sand is distributed quite generally over the state and differs only slightly throughout the whole area. The recognition of the fact that a given soil type in any particular climate and under

similar conditions of drainang is bound to be much the same regardless of the location where it is found in a new idea to the highway engineer and not a very old one to the agricultural soil expert. The work of the Bureau of Soils together with our own state agencies has made soil mapping for highway purposes a practical possibility although this work was conceived and carried out almost exclusively for the uses of agriculture and forestry.*

About 100 different types of soil have been identified and mapped in Michigan up to the present time. While this may seem a large number it should be borne in mind that once a type is recognized and tested, very little future testing will be necessary. If every different soil encountered on a highway had to be tested in the laboratory the expense and labor involved would be prohibitive. The value of the Bureau of Soils maps is that they indicate the location of the various types, so that when the characteristics of all types have been determined the simple identification of the type will,in most instances, be sufficient to stamp the subgrade as good or bad.

How Surveys Are Made. — The pavement condition survey party consists of one engineer familiar with construction and three assistants. Two of these assistants chain the pavement, marking it at every 20 feet and painting the number every 100 feet. The third assistant accompanies the engineer following the chaining party. The engineer and this assistant walk along opposite sides of the pavement locating the cracks and sketching them on specially prepared cross-section paper. All surface defects, such as pitting, scaling, spalling, hair checks, etc., are noted on the sketch. About 4 miles of pavement is an average day's work for this party.

A soil surveyor skilled in soil mapping follows the pavement party and uses the painted stations to locate the boundaries of the various soil types. A strip of soil 200 feet wide is mapped. After the mapping is completed the soil surveyor returns over the same route and selects typical soil samples which are sent to the laboratory for routine tests. A sufficient number of samples are tested to determine the extreme upper and lower limits of variation within the type.

Both the pavement condition and the soil mediately upon completion of the field work and the information is transferred to the original plan which is on a scale of 100 feet to the inch. This sketch is easily readable when the work is done by a neat draftsman and the complete results may then be easily studied or compared. The type of soil, and depth of the roadway in the soil profile, the grades, cross section, surface and subdrainage are all noted and may be read at a glance. Surface data sheets of the pavement survey are prepared in such a way that separate sections of road may be compared slab by slab. The surface data sheets give the slab lengths, number and kind of cracks, the pavement classification based ûpon the length of the unbroken slab and the area of the pieces of broken slab, the amount of scaling, spalling, and hair checking, etc.

A study of one phase of the soil survey—the subsidence of fills in peat marshes—has been practically completed. The fills were cross-sectioned by borings so as to determine the actual shape of the floating fill. The classification of the peat strata was made in accordance with the system developed largely by Dr. Alfred P. Dachnowski, of the Bureau of Plant Industry of the United States Department of Agriculture. Testing of peats in accordance with the standard soil methods is impossible since oxidation takes places unless the sample is kept continually moist with the result that a totally different class of material remains. No screen analysis is practicable and shrinkage tests and bearing values must be obtained from the moist material without initial compression.

*Methods of making soil surveys for highways using Bureau of Soils maps are discussed by A. C. Rose in Public Roads, "Practical field tests for subgrade soils," v. 5, No. 6, August, 1924, "Field methods used in subgrade surveys," v. 6, No. 5, July, 1925, and "The present status of subgrade studies," v. 6, No. 7, September, 1925.

Grade Crossing Elimination in Iowa.—During 1925, 13 grade crossings were eliminated in Iowa by the separation of grades through the construction of viaducts carrying either the road or the railroad above the other. There were 16 crossings on which danger was eliminated by other means. There were 21 additional projects listed, 2 additional surveys made, and plans and estimates made for 20 out of which 16 were satisfactorily adjusted and 4 appealed to the railroad commission. Since Dec. 1, 1922, when railroad crossing work was first systematically undertaken there have been 704 dangerous crossings listed for improvement in 554 projects. Plans and estimates have been prepared for 348 of these. Eighty-six of these crossings have been eliminated by grade separation and 229 otherwise improved.

Over 2,000,000 New Cars in First Half of 1926.—Automobile production in the United States and Canada for the first half of 1926 will approximate 2,175,000 units. This forecast is based on May production figures, announced by the United States Department of Commerce and an estimate for June. This would make the first six months' production exceed that of the corresponding period of last year by approximately 230,000 or 12 per cent.

Bituminous Paving Plant Inspection

Tentative Recommended Practice[1] Submitted in Committee Reporte Presented June 22 at 29th Annual Meeting of American Society for Testing Materials

Sampling

1. Samples of each material used in the mixture should be submitted to the laboratory at the beginning of work on each contract. Should the source of supply of any material received change from that represented by the original sample, new samples should be submitted. Samples of all materials rejected by the inspector should be forwarded to the laboratory.

2. The inspector should submit samples in the following quantities to the laboratory:

One quart of asphalt cement;
Five pounds of filler;
Five pounds of asphalt sand;
Five pounds of screenings;
Fifteen to twenty pounds of crushed stone.

(a) Sand.—Samples of sand will generally be taken from each carload received. If it has been determined that the sand being supplied is of a uniform grade, and a visual inspection shows the sand in each car to be similar to satisfactory material received in previous shipments, one sample may be taken to represent as many as three carloads, but the inspector must combine material from each of the several cars in making up his sample. The sand shall be sampled in accordance with the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials (Serial Designation: D 75) of the American Society for Testing Materials.[2].

(b) Filler.—One sample made up from filler representing 8 to 10 sacks in scattered positions shall be collected from each car. The individual samples from each sack should be combined and quartered until a sample weighing approximately 105 g. is obtained.

(c) Screenings.—The screenings shall be sampled in accordance with the Standard Methods D 75.

(d) Stone.—Shipments of stone are to be examined for soundness, freedom from dust and dirt, and cubical shapes. The stone shall be sampled in accordance with the Standard Methods D 75.

(e) Asphalt Cement.—The inspector will take, as far in advance of use as possible, a sample of the asphalt cement, sampling it in accordance with the Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140) of the American Society for Testing Materials.[3]

Field Testing of Materials

3. **(a) Sand.**—The sand should be tested in accordance with the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material, Except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of American Society for Testing Materials[4] except that the sample for mechanical analysis should consist of at least 100 g. instead of 50 g. as specified.

When two or more grades of sand are being received for use in combination, separate mechanical analysis should be made on shipments of each variety, and the resultant combinations calcuated from the gradations, and shown on the daily report. The proportions in which sands are combined should also be shown on the report.

(b) Filler.—The sample should be thoroughly dried and 100 g. accurately weighed and the amount passing the No. 200 sieve should be determined in accordance with the method for determining the fineness of portland cement as given in Sections 32 to 35 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials[4]. Providing any appreciable amount of filler is retained on the No. 200 sieve, the mechanical analysis of this coarser material should be obtained in the same manner and with the same sieves as were used in testing the sand.

(c) Screenings.—The size of the dried sample used for testing should be not less than 250 g., and if the screenings are very coarse, or contain a considerable percentage of sizes larger than ½ in. in diameter, an amount up to 500 g. may be used. In either case, the sample should be placed on a No. 10 sieve and divided into two parts, one being the part retained and the other the part passing this sieve. The percentage represented by each part should be determined. If the amount passing the No. 10 sieve is much greater than 100 g., a portion of it, after thorough mixing, may be selected by quartering and this portion

[1]Criticisms of this Tentative Recommended Practice are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.
[2]1924 Book of A.S.T.M. Standards.
[3]A.S.T.M. Standards adopted in 1925.
[4]1924 Book of A.S.T.M. Standards.

sifted through the various sieves. The percentage thus determined should be reduced proportionately to percentages of the original total sample. The entire part of the sample which was retained on the No. 10 sieve should be screened over the various coarser screens that may be required.

(d) Stone.—The stone should be graded in accordance with the Standard Method of Mechanical Analysis of Broken Stone or Broken Slag, Except Aggregates Used in Cement Concrete (Serial Designation: D 18) of the American Society for Testing Materials[5]. When stone is being used from a large stock pile, frequent screen tests should be made as the work progresses.

(e) Asphalt Cement.—The inspector shall make penetration tests on the asphalt cement in daily use in accordance with the Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials[6].

A working range of ten points in the penetration of asphalt cement should be set for each contract, and if results should show a deviation above the maximum or below the minimum, a check determination should be made. If tests should show a deviation of 3 points or more above or below the limits set, the use of this material should be stopped immediately and the laboratory communicated with for advice.

Inspection of Plant Operation

4. Proportions, General.—The inspector will receive instructions in regard to the desired proportion of each ingredient that enters into the mixture. He must then make all necessary determinations of the accuracy of scales, of the volume of the various containers used in the proportioning, and proportioned by volume, the weight per cubic foot of the various materials. He should check at frequent intervals the various scales used in determining weights of each material and check weights per unit of volume of each material when volumetric proportioning is used.

Asphalt cement must always be measured by weight.

5. Volumetric Proportioning of Dry Aggregates.—When the dried and heated sand, stone or dust are measured by volume, their weights per cubic foot hot, and the volume of the containers in which they are to be measured, must be determined in order to compute the total weight.

6. Volumetric Proportioning of Wet Aggregates.—When wet sand, stone or screenings are being measured by volume, the moisture content of each must be determined by selecting a sample, drying it and calculating the percentage of moisture from the wet and dry weights, these amounts being deducted from the weights of each material forming the total batch in calculating the required amount of asphalt cement. The percentage of moisture in the aggregates should always be entered on the daily report. The determination must be made frequently on sand and fine screenings. Weight per cubic foot of materials and volume of containers in which measuring is to be effected must be determined, except where wheelbarrows are being used, and means are provided for weighing the barrows, heavy and light.

7. Proportion by Weight.—If the sand, stone or dust are being measured by weight, the accuracy of the scales in use should be checked by the use of a 50-lb. standard weight. An approximate check can also be obtained by determining, on other scales, the average weight of a cubic foot of each material, and then comparing the number of cubic feet, calculated from this, with the volume actually occupied by the fixed weight in use.

Whenever possible, entire loads of the mixture should be weighed.

To determine the amount of bitumen obtained from a given amount of asphalt cement, the following approximate figures may be used: Residual or oil asphalts (Mexican, California, Texas, etc.) contain 99 to 100 per cent of bitumen; refined Bermudez, 94 to 96 per cent of bitumen; refined Trinidad, 75 per cent. When Trinidad or Bermudez asphalt cement is to be used, the actual percentage of bitumen should be secured from the laboratory.

8. Inspection of Process of Combinations.—(a) When two or more kinds of aggregates are combined on the ground by measuring in wheelbarrows, to produce the final mixture, the barrows must be carefully struck off to a level surface. Irregular heaping of barrows shall not be permitted. When the process of feeding is continuous, the proportioning of the mixture must be accomplished on the mixing platform.

(b) The inspector should take the temperatures of the ingredients (especially the mineral aggregate) and of the mixtures as frequently as possible and assist the plant employes in every way in keeping the temperatures uniform by notifying the plant foreman of any marked changes that he may observe.

(c) The inspector should note whether the scales on the mixing platform are being handled carefully, taking care that the bucket swings free during weighing, and that the beam is brought to a floating position and the bucket is drained completely for each batch. He should also check, or have the mixerman check, the tare weight of the empty asphalt

[5]1924 Books of A.S.T.M. Standards.
[6]A.S.T.M. Standard adopted in 1925.

bucket at frequent intervals, so as to take care of any increase or decrease in the amount of asphalt clinging to the bucket after each pouring. Particular attention must be paid to this point in cool weather and, in general, at times when there is a long interval between loads.

ASPHALT PLANT REPORT

	COUNTY	TWP. OR BORO. OR CITY
	ROUTE OR APPL. OR STREET	SEC. NO.

Date........ 19... Weather........ Temp. A. M........ P. M........ F. A. P. No........ Eng. Dist........
Type of Const........ Type of Plant........ Location of Plant........
Contractor........ Amount of Contract........
Binder or S. C. Sta........ to Sta........ Lineal ft. S. C. or Binder........
W. S. or B. C. Sta........ to Sta........ Lineal ft. W. S. or B. C........

Work	Ave. Temp.	No. Batches	No. Loads	Hrs. in Operation	Sq. Yd. Laid	Materials	Kind or Brand	Tons on Hand	Tons Used
						Refined Asphalt			
Binder or S. C.						Flux			
W. S. or B. C.						Asphaltic Cement			
						Filler (Dust)			
Binder or S. C., lb. per sq. yd.						Portland Cement			
W. S. or B. C., lb. per sq. yd.						Sand			
Total lb. per sq. yd.									
No. sq. yd. laid to date, Completed Pvt.									
No. sq. yd. laid to-day, Completed Pvt.						Gravel			
No. sq. yd. laid, total, Completed Pvt.						Crushed Stone			
Plant Labor*	No.	Hours	Total Hours			Screenings			
Foremen						Coal			
Engineers						Coke			
Skilled Labor						Fuel Oil (Gal.)			
Unskilled Labor						Lub. Oil (Gal.)			
Trucks									
Total Hours									

Sampled From	Sand				Stone				Screenings		Penetrations No.	Penetrations Test	Samples to Laboratory	
Per Cent Passing 200													W. S.	
80													B. C.	
40													S. C.	
10													A. C.	
$\frac{1}{4}$ in.													R. A.	
$\frac{1}{2}$ in.														
$\frac{3}{4}$ in.													Filler	
1 in.													Sand	
$1\frac{1}{2}$ in.											Av. Temp. A. C		Screenings	
Ret. on $1\frac{1}{2}$ in.											Tank No. 1	Tank No. 2	Stone	......
Total														

BATCH WEIGHTS AND PERCENTAGE OF MIXTURES

Material	Binder (lb.)	Per Cent	W. S. (lb.)	Per Cent	B. C. (lb.)	Per Cent	S. C. (lb.)	Per Cent	
A. C.									
Filler (Dust)									
Sand									
Screenings									
Stone									
Total									

Time Arrived........ Record of Official Inspections........
Beginning of Operation........ Calculations........ Notes to Lab........ Remarks........
Time Taken for Lunch........ Shown on reverse side (check items to which reference is made).
Time Departed........ ....Inspector

Form for Report in Asphalt Paving Plant

(d) The inspector should make certain that the mixerman allows the mineral aggregates to become thoroughly mixed before the addition of the asphalt cement.

(e) Should the aggregate be of improper temperature in the weighing box, the inspector should endeavor to prevent the incorporation of asphalt cement and in this way avoid the unnecessary loss of the batch of completed mixture. The desired temperatures at the plant will depend upon the kind of mixture being prepared, the kind of asphalt being used, the weather conditions, and the length of haul. The best temperature for raking, on the work, will be from 149 to 163° C. (300 to 325° F.) for sheet asphalt. Mixtures which contain a high amount of filler, or are prepared with Trinidad asphalt, will require slightly higher temperatures for proper raking. Mixtures which are made up chiefly of stone should range between temperatures of 107 and 149° C. (225 and 300° F.) in order to preserve a proper coating of asphalt on the surface of the stone. The inspector should be instructed as to the temperature range fixed for each contract, which will be governed by conditions peculiar to this contract. In no case should sheet asphalt topping be allowed to leave the plant which is at a temperature higher than 191° C. (375° F.) or bituminous concrete which is higher than 163° C. (325° F.) at the time of dropping from the mixer. Overheated aggregate may be cooled in the mixer before adding the asphalt, but material cooled in the mixer to a point below the set maximum temperatures, after the asphalt has been added, will not be acceptable. The lowest acceptable temperature on the work should be about 107° C. (225° F.) for mixtures containing a high percentage of stone, or about 121° C. (250° F.) for sheet-asphalt wearing surface. It is to be understood, however, that these temperatures are not recommended, and that only occasional batches should be accepted.

9. Daily Sampling of Materials and Mixtures.—(a) At the beginning of operations on a given contract, the sample of each grade of material taken should be numbered serially, starting at number one and continuing until the completion of the work, care being taken that these series are not broken or over-lapped,

but are kept in direct sequence. These numbers should be scratched or punched clearly on the tin cans, and marked with ink on the surface of bituminous-concrete or similar sample containers.

Daily samples should be selected and forwarded at the end of the day's work to the laboratory in a manner to arrive at the laboratory in the shortest possible time.

(b) In the case of material having passed through the drying and heating processes, the sample should be secured by passing a shovel or pan quickly through the stream of hot material as it flows from the storage bin.

This operation should be repeated three or four times at intervals, the different lots combined, sampled and graded as described. Bin material shall be tested at least once each day and the results recorded on plant report. The results of this test will show:

(1) When blended materials are being used, whether mixing is being carried on satisfactorily.

(2) Whether separation of fine and coarse aggregate has been complete. (If the dried sand is contaminated with stone, steps should be taken to ascentain the cause and correction made.)

(3) Whether the results of the mechanical analyses of the various aggregates have been increased or decreased in the drying and screening processes.

(c) In the case of asphalt cement, a daily sample should be taken for laboratory tests of each tank or still of asphalt cement used in the day's work. The samples should be placed in 2 or 3-oz. tin boxes, the boxes carefully cleaned and the lids closed tightly. The inspector should make his penetration tests on these samples after which they should be forwarded to the laboratory, taking care to drain all water from the needle holes after testing.

(d) In the case of sheet asphalt, a daily sample of the sheet asphalt wearing surface should be obtained. This should be taken in a small quantity at a time, from not less than ten, and preferably more, separate batches, molding the portions into the container provided for the purpose.

(e) In the sampling of bituminous concrete either of the two methods given below may be used:

(1) Small portions from a number of batches are taken and stored on a metal plate until near the end of the day, when the entire mass is reheated, care being exercised not to apply too great heat, mixed thoroughly and the day's sample selected in small portions from this mass.

(2) In the case of dense bituminous concrete mixtures the samples may be taken by collecting portions from one or more batches on a large shovel, thoroughly mixing while still warm and taking a small scoopfull which is placed directly in the carton, this operation to be repeated as often as possible and thus representing a maximum number of batches. In either of these methods, care must be taken to avoid segration of either store or bituminous mortar. In selecting the portions of the sample, care should be taken to scrape away the top material in the load, so as to avoid dust or any segregated unrepresentative mixture.

(f) Uniformity samples are to be taken on request and in the following manner:

(1) Select three separate samples from three separate and distinct spots in a batch, placing each sample in a separate container.

(2) Label each container distinctly "Uniformity Sample," giving also the temperature and length of time the batch was mixed.

10. Daily Reports.—The inspector should fill out his reports in ink on the form provided, giving all the required information, and should mail the report of the day's work at the end of the day's work.

A recommended type of report form is shown herewith, which may be elaborated on to meet all individual requirements but essential information pertinent to any project is included.

All data pertinent to the work not covered by the set form should be given on the reverse side of the report sheet. Communications of exceptional importance only are to be included under a separate head.

Reports should be submitted daily, whether the plant is in operation or not, excepting when work is suspended for several days then the last report must state why, and for what periods, work has been discontinued.

Hug Dual Tire Adapter

It is understood that the Hug Co., Highland, Ill., is now making arrangements for the production of its dual tire adapters on a scale large enough to exceed their own requirements for trucks, and meet the popular demand for this practical piece of equipment in the general roadbuilding field. This tire adapter which is used as standard equipment on all Hug trucks fits like an ordinary rim on a regular wheel, and the tires then fit on the adapter. By the use of this adapter, dual tires can be mounted on the same wheel as used for single tires, thereby not making it necessary to discard wheels when making the change from single to dual or dual to single tires. The Hug adapter also simplifies the change of tires, as tires can be changed without removing the wheel from the axle. The Hug dual tire adapter, like many other distinctive Hug features, was originally designed by C. J. Hug for use exclusively on Hug roadbuilder trucks.

The Dust Problem on Gravel Roads

Experiences of Various States in the Middle West Outlined in Paper Presented at Annual Meeting of Mississippi Valley Conference of State Highway Departments

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A canvass of eight central western states shows that the total mileage on their respective state systems is approximately 60,000 miles. Of this approximately 23,000 miles are surfaced with gravel. These highways, by virtue of being on the state systems, are naturallly the more important ones and those which carry more than average traffic.

Needless to say, the dust problem on these highways is beginning to attract considerable attention and we find practically all states experimenting with various dust palliatives in trying to solve their difficulties. While there are thousands of miles of dirt road on the main routes that contribute to the dust nuisance, the remarks in this paper will be confined mainly to gravel roads. Experience has shown that when traffic reaches 500 or more vehicles per day on a gravel road, some form of surface treatment is necessary in order (1) to provide for safety; (2) to protect the original investment by conserving materials; (3) to improve the efficiency of the highway.

The most common palliatives used thus far by the various states are calcium chloride, light asphalt road oils, light tars and medium asphalts.

Calcium Chloride Treatment.—Calcium chloride has been used quite extensively by a number of the states in combating the dust nuisance. This type of treatment is fairly satisfactory, but it requires the regular patrol operations to keep the surface smoothed up at all times and requires also at least two treatments per season. Calcium chloride should not be used on gravel surfaces having a large clay content as the moisture drawn from the air would tend to make the surface slippery in the same manner as a shower of rain. In treating a gravel road with calcium chloride, the first thing to do is to properly shape the surface of the road to a uniform cross section. This is followed by an application of about ¾ to 1 lb. of calcium chloride per square yard distributed with an ordinary lime sower or similar device. This treatment should be followed by a second treatment of about ¾ lb. per square yard from a month to six weeks later. If the season should be an unusually dry one it may be found necessary to treat the surface a third time with a very light application. Experience has shown that approximately 2 lbs. per square yard per season works out very satisfactorily on the average gravel road. Some prefer two applications whereas others believe three applications using smaller quantities for each application are more satisfactory. This would mean that the cost per season for material and labor in applying the treatment would vary from 3 cents to 5 cents per square yard. The time and expense of the patrolman in daily patroling the surface should be included which would add approximately $150 to $200 per mile per year, making a total cost per mile of between $400 and $600, depending on width treated. The calcium chloride treatment is quite satisfactory in keeping the dust down and holding material on surface, but it has no permanent effect.

Light Asphaltic Road Oil.—Light asphaltic road oils have been used to some extent on gravel roads but to a greater extent on dirt roads. It may be stated that this type of treatment will also keep the dust down and provide a satisfactory riding surface for a limited time. The oil also waterproofs the surface to the extent that it will shed water very readily during rainy spells. The one disadvantage in this type of treatment is that the surface will gradually become smooth and shiny in spots and as the oil evaporates the surface will start to disintegrate and thus cause a very uneven riding surface. This may be eliminated to a certain extent by keeping a light mulch of fine material on the surface at all times and grading it from one side to the other, thus preventing a crust from forming. Usually about ½ gal. of oil per square yard will suffice on the average gravel road. However, it often becomes necessary to make a light second application later in the season to preserve the original condition. The light oil surface treatment will cost approximately $350 per mile per year, plus the patrol maintenance cost which will bring the total cost per season between $500 and $600 per mile or about 4½ cents to 6 cents per square yard. Treatments the following year will require less oil per square yard and thus the cost the

second year will be decreased slightly. The road should be scarified annually and it is very necessary that these treatments should be followed up from year to year if a uniform surface is to be maintained. If this is not done the surface will soon disintegrate and become very rough.

Light Tar Treatments.—More miles of gravel road have been treated with light tars than with any other dust palliative except calcium chloride. In general there have been three methods employed; (1) that which provides a skin treatment where the penetration is less than 1 in.; (2) a treatment where a penetration of approximately 1½ in. to 2 in. is attained by mechanically mixing the tar and surface gravel with a grader and allowing traffic to compact the material; (3) where the surface materials are mechanically mixed the same as in case two, and a light roller is used to compact the treated portion. The first named treatment has been used a good deal in several states with considerable success but that type of treatment requires annual scarifying, reshaping and retreatment. The surface will not usually go through the winter season without being broken up by winter traffic and therefore requires scarifying each spring.

The Skin Treatment.—The skin treatment may be briefly outlined as follows:

The road to be treated is brought to uniform cross section and excess loose material is removed from the surface by a power sweeper. After the sweeping operations are completed, the surface of exposed metal should present a mosaic appearance. An application of about 1/6 gal. per square yard is then applied with a power distributor. Tar may be heated not to exceed 125° F. to facilitate distribution and penetration. This is allowed to penetrate for at least 48 hours. No absorbent is used after the first application of tar. If traffic cannot be conveniently shut off it is allowed to move over it. The second application of about ⅙ gal. per square yard is applied from two days to a week later, this application being immediately followed with coarse sand or pea gravel. If the tar shows a tendency to bleed, more sand should be applied. Within a few days, traffic will gradually iron out this surface making it appear very much like a bituminous macadam or an asphalt surface. The penetration, however, is from ½ in. to ¾ in. Any holes that may appear in the surface are patched from time to time by material consisting of a mixture of 17 gals. of light tar mixed with 1 cu. yd. of coarse sand. This treatment has been used quite extensively in the states of Maine, New Hampshire and other eastern states with considerable success but it has been found necessary to scarify and retreat each year. The annual cost will vary from 8 cents to 11 cents per square yard for the first year. Subsequent treatments will decrease slightly due to the fact that less tar is required in succeeding years.

The Mixing Method. (Traffic Bound).—This method was especially devised to do away with the annual scarifying and retreatment operations and it is especially adapted to gravel roads having an inch or two of loose material on the surface. Under this method the road is brought to uniform cross section and it is quite desirable to have some loose material on the surface. An application of about ¼ to ⅓ gal. per square yard is then placed on the entire surface. The amount of tar will depend somewhat on the porosity and the absorbent power of the surface materials. Immediately following the first treatment, a large blade grader with blade set at an angle of approximately 45 degrees and at a depth of ¾ in. to 1 in. moves the material a few feet beyond the center of the road. The distributor immediately follows the large grader with an additional ¼ to ⅓ gal. per square yard. The material previously moved to the center of the road is them moved back over the freshly applied tar. The same operation is followed for the other half of the road and in order to get a thorough mixture of the tar and surface gravel the entire surface should be moved back and forth several times with the grader. After traffic has been allowed to use the road for a week or ten days, the necessity of a light seal coat may be easily determined. Uusually the movement of traffic over the road irons out the surface to such an extent that some of the tar works up to the top and sufficiently seals the surface so that an additional treatment is not necessary. However, if it is found that the tar does not readily work to the surface a light seal coat followed with an absorbent of coarse sand is advisable. Extreme care should be exercised not to use too much tar, for if there is too much binder present the surface is apt to shove or wrinkle. With this method it has been found that a crust or mat of 1½ in. to 2 in. in thickness is built up. The amount of tar required varies from ⅝ to ¾ gal. per square yard and the cost varies from 9 cents to 14 cents. While experiments with this method have only been in service for two or three years, it is safe to say that under this treatment a reasonably smooth surface may be maintained for several years with but a light application every two or three years. The original cost per mile on an 18 ft. width is from $900 to $1200 per mile. The succeeding years the cost will depend on the amount of patching necessary and this is usually very small if the original treatment

was properly placed so that over a four or five year period the average cost per mile is cut down to approximately $600 or $700. It is unnecessary to scarify this surface each year as is the case with the skin treatment outlined above.

The one emphatic complaint that motorists have against oiling or tarring of any description is that their cars get spattered with oil or bitumen and this causes them extra expense and inconvenience. By treating a road under the mixing method this objection is practically eliminated, as traffic is allowed to use one half of the road while the other half is being treated. Experience has also shown that by immediately mixing the bitumen with gravel that the resultant mixture is not readily picked up by the moving vehicle but on the contrary traffic tends to compact the surface.

The Mixing and Rolling Method.—This method is the same as the mixing method except that instead of allowing traffic to iron out the surface, a light roller of not more than 5 tons in weight is used to compact the material. The advantage in this method is that the surface is smooth by rolling the entire width immediately after the mixing has taken place and traffic will not be inclined to follow the same rut. In other words, it will be distributed evenly over the entire surface whereas in the traffic bound mixing methods vehicles are inclined to follow the ruts of the vehicle that preceded. The cost of the mixing and rolling method is practically the same as the preceding method.

Medium Asphalt.—Treatment with this material is somewhat different than with light tars but the resultant surface is practically the same. Usually it is applied in two applications about six weeks apart. After the first application a planer or drag is used constantly over the surface at the same time allowing traffic to iron it out. The second application is placed about six weeks later and is followed with a covering of coarse sand. While there have been but a few miles of gravel roads treated by this method in Wisconsin, it is believed that satisfactory results may be obtained with medium asphalt.

Conclusion.—It has not been the intention of this paper to cover in detail the various operations in the surface treatment work, but on the contrary it is intended to bring out a few of the high lights and experiences of the various states in the central west. Surface treatments render a definite service to the road user as well as to the one who lives along the highways. The expenditures can be easily justified where traffic is heavy enough to warrant the treatment. This is especially true when you consider that on the average gravel road which has a traffic of 500 or more vehicles per day that the annual loss in material on an 18 ft. width is from 300 to 400 cu. yds. per mile. Figuring this at $2.00 per cu. yd. in place we would have $600 to $800 per mile loss in material each year if it is not surface treated. No community is so well supplied with materials that they can afford to lose this amount each year indefinitely. Even if the road will eventually be paved with a durable pavement, materials must be conserved for the secondary and local roads. In addition to making the saving in material there is elimination of the dust nuisance which has been responsible (1) for many of the highway accidents and insanitary conditions, (2) for deterioration of motor equipment, clothing, buildings, furnishings and farm crops, and (3) for decrease in efficiency of the highway. When you consider what this means on the many thousands of miles of gravel roads on the various state systems it is obvious that a surface treatment renders not only a true highway service but it is a sound business proposition. It does not take the place of a durable pavement but it bridges the gap between the plain low type surface and the durable pavement. It is a maintenance and not a construction problem.

Dynamite in Snow Removal

Dynamite was used in breaking up three snow slides on the Fall River Road, the highest road in the National Park System. This road reaches an elevation of 11,976 ft. It connects Estes Park, at the eastern edge of Rocky Mountain National Park, with Grand Lake, on the western side of the divide. The road crosses the path of three steep gulches on the south side of Mt. Chapin. Every winter snow slides sweep down these gulches. This year the lowest of the three slides ran a greater volume of snow than in any of the five preceding years since the road was completed. The snow slide spread out in a fan shape, and covered 410 feet of road with a tumbled mass of snow, from 5 ft. or more than 20 ft. in depth.

By means of post hole augurs, holes were dug in the snow, down to the road level. Each of these holes was then loaded with from 25 to 50 lb. of dynamite, which was tamped in with snow above. The charges were detonated with a battery, about a dozen holes being fired at each shot. In this manner, a V-shaped trough was cut through the snow slide, and men with shovels finished a trench wide enough for trucks to pass through.

The middle and upper slides were not particularly heavy, and were opened in a similar manner.

All Western Road Show

The beautiful Marina of the 1915 Panama-Pacific International Exposition grounds, in San Francisco, Cal., will be the scene of the second All-Western Road Show, Oct. 7 to 15, inclusive, according to President Tracy W. Harron, of the Western Construction Equipment Distributors, under whose auspices the show will be staged. Close to 1,000,000 sq. ft. of space will be available for exhibitors, both under canvas and outdoors, on the Marina, which was the scene of last year's highly successful initial All-Western Road Show. The Marina is situated within ten minutes by street-car or auto, to the heart of San Francisco's downtown business district.

This year's road show will be staged in conjunction with conventions of contracting, state and county official, engineering, rock producing and good roads organizations of the entire Pacific Coast and Rocky Mountain states, 11 states being included in the personnel of the sponsoring association. Advance orders for space are stated already to exceed the gross space used by exhibitors last year, and the show management hopes to be able to accommodate all applications to exhibit at the exposition. Where last year's show afforded to many thousands of visitors a splendid opportunity to view the most modern design and engineering in road building machinery and practice, it is hoped that this year's attendance figures will greatly exceed those of 1925, and the committee proposes maintaining an efficient registration department to properly catalogue all show visitors.

The show will be held nine days, opening Thursday morning, Oct. 7, at 10 a. m., and running through the following Saturday and Sunday, also Columbus Day, closing on Friday, Oct. 15, at 5:30 p. m. It is believed that executives, officials and experts will welcome the opportunity given their job foreman and machine operators, engaged during week-days, to view the exhibits on Saturday and Sunday.

Arrangements are under way for special trains and motor caravans to bring visitors to San Francisco from principal trade centers of the west, and those in charge of the show look forward to the presence of many eastern and southern visitors. A hotels-housing committee will be organized to assure adequate accommodations to those attending the road show, or participating in one or more of the numerous conventions, national and regional meetings, and conferences scheduled from Oct. 7 to 15.

The U. S. Bureau of Public Roads, represented by Bureau Chief Thomas H. MacDonald, has announced that the largest exhibit used by the Bureau will be on display at the San Francisco Road Show.

The general committee for the 1926 All-Western Road Show comprises T. W. Harron, President, San Francisco; Edward R. Bacon, Vice-President, San Francisco; L. E. Murphy, Treasurer, San Francisco; P. H. Curtis, Los Angeles, Executive Secretary; C. C. Chamberlin, A. E. Mason, C. A. Garfield, O. R. Peterson, Carl Kratz, F. C. Edmonds, W. E. Hewitt, S. S. Smith, E. S. Jenison, W. H. Mason, J. P. Sherbesman, and Stanley Kulp, San Francisco; Frank Gaines and Claude Faw, Berkeley; J. T. Alm, and Charles A. Spears, Oakland; Dan R. Brown, Ed Crowley, George Monfort, L. M. Railsback and L. H. Garlinghouse, Los Angeles; F. C. Stannard, Salt Lake City; R. L. Balzer, W. E. Feenaughty and F. A. Kingston, Portland; F. C. Schoen and L. A. Snow, Seattle; and L. L. Clinton, Denver.

General headquarters have been established by the Committee for the 1926 All-Western Road Show, at 625 Market St., San Francisco, under the direction of P. H. Curtis, Executive Secretary.

Welded Pipe Lines in Paving Job

Substitution of welded pipe lines for the former system of screw pipe is being tried on concrete paving projects in Division VII, of the California State Highway System. A description of the plan used on the Jahn & Bressi contract, north of San Juan Capistrano, is given by C. N. Ainley, Resident Engineer, in June California Highways.

Jahn & Bressi contracted with the pipe company for the complete handling of the pipe during the period of construction. The pipe used, secondhand boiler tubing, is strung out over portions of the job where it is to be needed and is then welded by means of an acetylene torch. The cost of installing, which includes welding joints and pipe stubs for hydrants at 100-ft. intervals, was reported to have been 3½ ct. per ft. for 3 in. pipe and 5 ct. per ft. for 4 in. pipe.

With the joints laid end to end as unloaded from the truck, one man can average 35 welded joints per day. The time of welding in a stub for hydrants is about 10 minutes.

It is claimed the use of welded pipe has a number of advantages. The line can be shifted without danger of breaking, if ordinary care is used; a leak or break is easily repaired, and the line is readily disconnected with the torch for moving.

The boiler tubing with the welded joints used on this job will stand about 500 lb. pressure. It is asserted that there is no noticeable increase in friction head due to the use of this pipe; in fact, friction is decreased. Welded pipe has been used on two jobs with success.

Oil-Sand Road Building in Nevada

Construction Details of 10 Miles of Federal Aid Project Given in the Highway Magazine

By HOWARD M. LOY
Assistant State Highway Engineer, State Highway Department of Nevada

In the fall of 1924 the State Highway Department of Nevada completed 10 miles of oil-sand road in Nye County, south of Carrara. Federal aid was secured for the construction of this project, which is known as Nevada Federal Aid Project No. 46.

This section of road presented unusual difficulties because of its isolation, the sandy material of which the grade, and in fact the entire stretch of country, is composed, and the absence of any satisfactory surfacing material in the vicinity of the project.

This problem was solved by constructing what has been termed an oil-sand surface. Asphaltic road oil was shipped in tank cars to Carrara, the nearest railroad siding, and there transferred to distributor trucks and hauled to the project. The average haul from the railroad to the job was approximately 19 miles. The roadway on which this surface was placed was the abandoned railroad grade of the Las Vegas and Tonopah Railroad.

The Oil.—The specifications required that a sand-oil surface be used where the grade consisted of loose sand comparatively free from loam and dirt. They also required that the asphaltic road oil incorporated with the sand on the grade have an asphaltic content of not less than 50 per cent nor more than 65 per cent. The specifications further required of the road oil:

(a) A flash point of not less than 150 deg. F.

(b) Loss at 325 deg. F., five hours, not more than 50 per cent. Penetration of residue not less than 50, No. 2 Needle, 77 deg. F., 100 grams, five seconds.

(c) Solubility in carbon disulphide not less than 99 per cent.

Shoveling Sand Onto Fresh Application of Oil

Methods of Construction.—Concerning the methods of construction, the specifications read:

Cultivating Oiled Sand With Aid of 2½-Ton Caterpillar Tractor

(a) The roadway shall be trenched to a depth of approximately 4 in. The width of the trench at the bottom shall be the width of the finished surface shown on the plans. The material removed from the trench shall be piled along the shoulders to be used later for covering the road oil. The bottom of the trench shall be brought to a smooth, even surface.

(b) Road oil shall be distributed uniformly over the bottom of the trench at the rate of approximately 1 gal. per square yard and covered uniformly with sand to a depth of approximately 1 in.

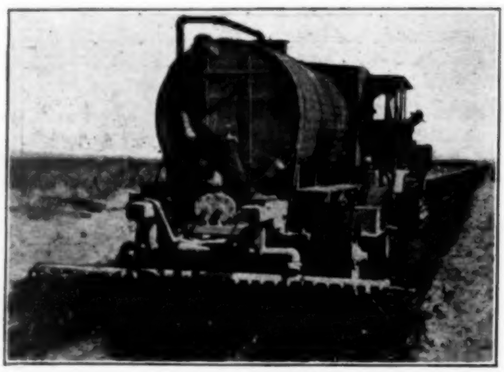
The sand and oil shall be cultivated until they are thoroughly mixed to a depth of about 2 in. below the original bottom of the trench.

A second application of road oil shall be made at the rate of approximately 1 gal. per square yard, and the cultivating continued until a uniform mixture of sand and oil is obtained and the surface presents a uniform appearance. If the surface is not uniform in contour after cultivating, it shall be thoroughly dragged until a uniform contour is presented.

(c) Sand shall then be spread over the sur-

face uniformly to a depth of approximately 1½ in. and a third application of road oil made at the rate of approximately 1 gal. per square yard. The road oil shall then be covered with sand spread uniformly to a depth of approximately 1 in. The sand and road oil shall be cultivated until they are thoroughly mixed. A fourth application of road oil shall be made at the rate of approximately 1 gal. per square yard and the cultivating continued until a uniform mixture of sand and oil is obtained and no pockets of free sand occur.

(d) Sand shall then be spread over the surface uniformly to a depth of approximately ½ in., and the road shall be thoroughly dragged and then opened to traffic. Dragging shall be continued for a period of one month and wherever bleeding occurs, additional sand shall be added to absorb the excess road oil.



Truck Distributing Oil

These specifications were modified to some degree as the work progressed and it was seen that the method could be improved upon. After a little experimenting the following procedure was decided upon and was followed out for practically all of the project:

Construction Procedure.—Upon the prepared subgrade an application of asphaltic road oil was made after which the roadway was cultivated with a double action light tractor disc harrow. Following the cultivation of the surface with the disc harrow, a second application of road oil was made. After the second application of oil, the entire surface was covered with sand from the shoulders and the surface again cultivated with the disc harrow. In addition to the cultivation with the disc harrow, a large road grader was used, first to assist in cultivation by pushing all the oiled sand material into a windrow to one side of the treated surface and then casting it into a windrow on the other side of the treated surface. After using the road grader as just mentioned, it was used to level up the treated surface to receive a third application of road oil.

This procedure was continued until the required amount of oil had been applied and the oil and sand thoroughly mixed, so that the surface presented a uniform appearance.

When the surface had attained a uniform appearance the large road grader was used to shape the surface with a slight crown, approximately two inches, after which operation a petrolithic road roller was used to compact the oil-sand surface. Following the compaction, a drag, 10 ft. wide by 20 ft. long, was used in conjunction with an ordinary roller, 3 ft. in diameter loaded with concrete and having a weight of approximately 175 lb. per inch of width, to secure a uniform even surface.

Amount of Oil Used.—Asphaltic road oil was received in tank cars, 10,000 and 12,000 gal. capacities, at Carrara, Nye County. Altogether 19 cars containing 202,566 gal. of oil having an asphaltic content of 60 to 65 per cent, and four cars containing 44,774 gal. of oil having an asphaltic content of 85 per cent, a total of 247,340 gal., was received.

This oil was used as follows:

Roadway only	233,625 gal.
18 turnouts, 2,400 sq. yd. at 3.79 gal per sq. yd.	9,096 gal.
Used for fuel, 60-65 per cent oil—and wasted	2,219 gal.
Used for repairing gravel surface—Station 1127 to 1235-35 during hauling. Three loads of 800 gallons each	2,400 gal.
Grand total	247,340

The oil surface yardage consisted of:

Roadway 10 feet wide, 10.05 miles long	58,913 Sq. Yds.
Turnouts	2,400 Sq. Yds.
Total	61,313 Sq. Yds.

The weight of the sand was estimated at 100 lb. per cubic foot, and that of the gravel at 125 lb. per cubic foot. The thickness of the oil-sand surface was assumed as 6 in. throughout, and the weight of the oil estimated at 7.75 lb. per gallon. In these figures no correction has been made for temperature of oil when applied, and the number of gallons applied is estimated from the capacities of the distributor truck tanks.

Four cars, 44,774 gal., of road oil, 85 per cent asphalt content, were used to complete the job. The application of this oil was made to vary according to the appearance of the different sections, enough being applied to secure the required uniform appearance.

No reservoir to receive oil deliveries was constructed, the tank cars in which the oil was received were used for storage, the state paying the demurrage accruing on account of delays in unloading. This amounted to $288, considerable less than the cost of building a suitable reservoir.

Application of Oil.—When the work started in March, 1924, the weather was cold and it was necessary to heat the oil in the tank cars so as to handle it. A small upright boiler, fired with oil, was used to supply steam for heating the oil in the car as well as to operate

a small rotary pump which pumped the oil from the heater to the trucks hauling oil to the job.

This outfit was continued in service during March and April when the weather became so warm that it was unnecessary to heat the oil before handling. The steam heater was discontinued and a rotary pump driven by a gas engine was used to pump the oil from the cars into the trucks. The last four cars of oil having an 85 per cent asphalt content required some heating in order to get the oil hot enough to handle.

The oil was hauled from Carrara to the job, an average haul of about 19 miles, in two distributor trucks. One of them had a tank capacity of 782 gal. with a pressure distributor consisting of a rotary pump driven from the transmission of the truck. The other truck was equipped with a tank having a capacity of 660 gal. with a pressure distributor operated by a gasoline motor supported on brackets at the rear of the truck. The two trucks were able to proceed to the job on their own power, but as soon as the sand was encountered it became necessary to assist them. For this purpose, the use of caterpillar tractors was resorted to. At first a 10-ton artillery type was used, but as the oil was applied the rolling resistance decreased and the trucks could be handled with a 2½ ton tractor, and at the last job, proceeded on their own power.

When not engaged in assisting the distributor trucks through the sandy section, the tractors were occupied in preparing the trench and subgrade, cultivating, rolling, and dragging.

The hauling was done over the old L. V. & T. Railroad grade which soon began to get very rough under the traffic. It was necessary to assign two men, and a small truck with which to haul gravel, to the duty of maintaining the road between Carrara and the job. This work was continued throughout the time devoted to the hauling of oil.

Costs.—Upon that portion of the road which had been graveled in 1923, namely, Station 1127 to Station 1238, the construction was modified in that less than half as much oil was used and the amount of sand added was just sufficient to blot or absorb the surplus oil.

The cost of this work was as follows:

Road oil F. O. B. Carrara	$14,417.83
Labor	13,170.02
Equipment Rental, Supplies and Repairs	30,401.99
Total	$57,989.84
Cost per square yard of completed road—61,313 sq. yds.	0.946

View of Completed Section of Oil-Sand Road

Tourist Traffic Survey in Wyoming

An intensive state wide survey of the tourist traffic in Wyoming is to be carried out during the first two weeks of July by the state highway department.

The plan calls for the distribution of 10,000 post cards to tourists during the period of the survey, the cards to be handled by garages, filling stations and hotels or resorts. Tourists are requested to take a card, if they have not already been supplied, and mail the card with the required information when they leave the State.

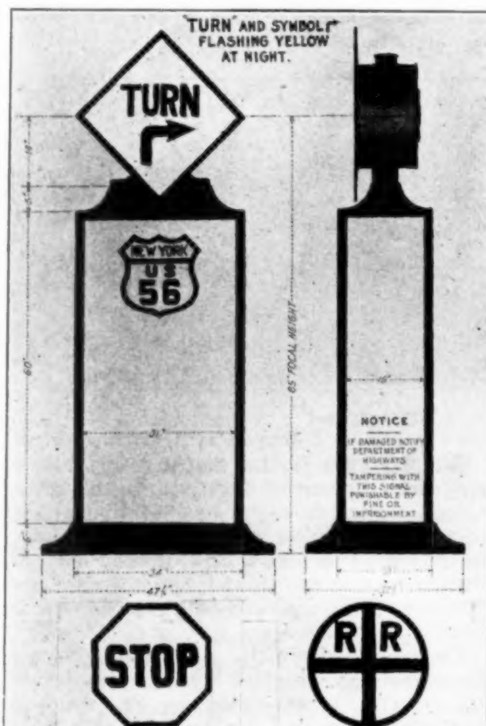
The post card, which on one side will carry the address of the state highway department, asks on the reverse side for the following information:

Name and home address.
Number in party.
Date and place entered Wyoming.
Date and place left Wyoming.
Approximate amount of money spent in state.
Trace route taken through state on small map printed on card.

The data secured on the cards will be compiled and the proper factors introduced to secure the true volume of traffic during the period under consideration, and thus through proper deduction the volume and value of the tourist traffic for the season may be computed with considerable accuracy.

New Interflash Highway Signal

The new highway signal of the Interflash Signal Corporation, 120 Broadway, New York City, is illustrated in color, shapes, dimensions and indications (words and symbols), it is built in entire conformity with the standards adopted and approved by the recent Hoover Conference on Street and Highway Safety, the United States Bureau of Public Roads, the Joint Board of Interstate Highways, and the Association of State Highway Officials. The Interflash highway signal is designed for both day and night service, as all parts of the words and symbols are illuminated at night by a flashing light. The pedestal of the signal



New Model Flashing Signal

is constructed in "Armco" Ingot Iron enameled white and set in a black enameled frame. The base is 47½ in. by 32½ in., while the focal height from base to center of the sign is 85 in. Direction sign can thus easily be placed upon it. The flashing signals are made of brass and aluminum painted Federal yellow with the words and symbols of glass. These flash yellow or red at night, as indicated by the drawings. The flashing mechanism and operating parts of the highway signal are the well-known standard Interflash type, used in all highway models manufactured by them and similar to that furnished by the Interflash Signal Corporation to the United States Lighthouse Service. They consist of flasher, patented thermo-siphon gage, regulator and Prest-O-Lite acetylene tank.

Curb and Gutter Ditcher

The accompanying illustration shows the new curb and gutter ditcher of the Barber-Greene Co., Aurora, Ill., excavating for forms for curb and gutter on a job in LaGrange, Ill., for which Albin Carlson is the contractor. This machine will cut a trench 32 in. wide and

Curb and Gutter Ditch in Operation on Gilbert Ave., La Grange, Ill.

3 ft. 6 in. deep at the rate of 5 ft. per minute. It has the same specifications as Barber-Greene standard ditcher, except that it has two bucket lines mounted in parallel. One bucket line cuts 21½ in. and the other 10½ in. It is stated that the machine is able to average 150 ft. an hour through the toughest digging, and often making runs of 2500 ft. per day.

Paving Intersection of Four Roads.—At a highway intersection about one mile west of Waupaca, Wis., four roads radiate at varying angles. Each road is paved at the intersection with concrete for a width of 40 ft. The corners formed by these intersecting roads are rounded to conform to a radius of from 25 to 75 ft.